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ART. L.—*On Photographing the Spectra of the Stars and Planets;* by HENRY DRAPER, M.D.

[Read before the National Academy of Sciences, Oct. 28th, 1879.]

FOR many years it has seemed probable that great interest would be attached to photographs of the spectra of the heavenly bodies, because they offer to us conditions of temperature and pressure that cannot be attained by any means known at present, on the earth. The especial point of interest is connected with considerations regarding the probable non-elementary nature of the so-called elementary bodies. There has long been a suspicion in the minds of scientific men that one or more truly elementary bodies would be found from which those substances which have not as yet been decomposed, are formed. The recent publications of Lockyer have attracted particular attention to this topic.

The most promising laboratory processes for accomplishing the dissociation of our present elements depend upon the action of heat, especially when accompanied by electrical influences, and upon relief of pressure. But the temperature we can employ is far below that found in the stars, which is comparable only with the heat of our Sun, and when in addition the application of heat is restricted by the narrow range of circumstances under which we can also reduce the pressure, complete success seems to be impracticable in the laboratory.

But in the stars, nebulæ and comets there is a multitude of experiments all ready performed for us with a variety of conditions of just the kind we need. It remains for us to observe

and interpret these results, and this is the direction I have sought to pursue.

There is but one mode of investigation that can add materially to the knowledge Astronomy has given us of the heavenly bodies; that is the spectroscopic. This in its turn is capable of a subdivision into two methods, one by the eye, the other by photography. Each of these has its special advantages and each its defects. The eye sees most easily the middle regions of the spectrum, and can appreciate exceedingly faint spectra; by the aid of micrometers it can map with precision the position of the Fraunhofer lines, and by estimation it can with tolerable accuracy approximate to the relative strength, breadth and character of these lines. The character of the spectrum lines is however of great value for the purposes we are now speaking of, and the greatest precision is needed. Photography, on the other hand, as applied to faint spectra, deals mainly with the more refrangible region, and cannot at present be employed in stellar work below the line F. Fortunately there is no break in the spectrum between the place where the eye leaves off and photography begins, and hence the two methods lend one another mutual assistance. The photograph when suitably accommodated with a standard reference spectrum from some known source, gives valuable indications as to the positions and all the peculiarities of the lines.

But the application of photography to the taking of stellar spectra is surrounded by obstacles. These are partly due to the small quantity of light to be dealt with, and partly to the fact that it is necessary to overcome the motion of the earth and other causes, such as atmospheric refraction, which seem to make a star change its place continually. The exposures of the sensitive plate require to be sometimes for two hours, even with a large telescope, and if during that time the image of the star at the focus of the telescope has changed place $\frac{1}{800}$ of an inch the light no longer falls on the slit of the spectroscope. The changes of the earth's atmosphere in regard to photographic transparency as well as by fog also offer impediments, and promote the chances of failure. There is often a yellow condition of the air, which may increase the length of exposure required forty times or more.

It will, from what has been said above, be readily perceived that a research such as this consumes a great deal of time, in fact these experiments and the preparations for them have extended over more than twelve years. A large telescope is required, and for many reasons the reflector at first seems most suitable. Recently, however, I have found that the refractor has also some special advantages.

In 1866 I had already constructed a silvered glass reflector

of 15½ inches aperture, which was commenced in 1858, and had taken with it many hundreds of photographs of the Moon. But as the mounting had been contrived for lunar photography and to avoid the Moon's motion in declination, the instrument was not suitable for the spectroscopic work contemplated. A reflector of twenty-eight inches aperture was therefore commenced in 1866, and in 1871 it was ready for use.

On May 29th, 1872, my first photograph of the spectrum of a star was taken, the spectrum of Vega being photographed by the aid of a quartz prism. At this time I did not happen to know that Dr. Huggins, who is so distinguished for his thorough and accurate researches on the visible portion of the spectra of the heavenly bodies, had already made some attempts in this direction, as is shown by the following paragraph from the Transactions of the Royal Society for 1864: "On the 27th of February, 1863, and on the 3d of March of the same year, when the spectrum of Sirius was caused to fall upon a sensitive collodion surface an intense spectrum of the more refrangible part was obtained. From want of accurate adjustment of the focus, or from the motion of the star not being exactly compensated by the clock movement, or from atmospheric tremors, the spectrum, though tolerably defined at the edges, presented no indications of lines. Our other investigations have hitherto prevented us from continuing these experiments farther; but we have not abandoned our intention of pursuing them."

During August, 1872, I took several photographs of the spectrum of Vega, and these showed four strong lines at the more refrangible end of the spectrum, the least refrangible being near G. On pursuing the subject and seeking to ascertain what substances gave rise to these lines, it became obvious that a photographic study of this part of the spectrum for the metals and non-metals was necessary to interpret the results. This of course opened out a large field for experiment, requiring many years for its study, and hence, as several physicists were engaging in the study of the spectra of the metals, I concluded to discontinue the experiments commenced in 1870 on the spectra of the metals and to confine the investigation mainly to the non-metals. The initial step was, however, to obtain a fine photograph of the normal solar spectrum, so that the wave lengths of the lines up to O [wave length 3440] might be determined with precision.

In the spring of 1873 I published a paper on the diffraction spectrum of the Sun, illustrated by a photograph embracing the region from wave length 4350 near G to 3440 near O, and in the fall of the same year took photographs of the spectra of several non-metals, notably nitrogen, carbon, and oxygen.

The experiments were interrupted, in the spring of 1874, by going to Washington to superintend the photographic preparations for the United States observations on the Transit of Venus.

Since that time my experiments have been divided into two parts, an astronomical portion occupying principally the summer season, and a laboratory portion during the rest of the year. The former consisted of photographs and observations on the spectra of the stars, planets and sun; the latter of photographic work on the spectra of the elements and particularly the non-metals, and has led to the discovery of oxygen in the sun.

In 1876, Dr. Huggins published a note in the Proceedings of the Royal Society, accompanied by a wood-cut of the spectrum of Vega, with a comparison solar spectrum. Seven lines were observed in the spectrum of Vega. In the summer and autumn of 1876 I made several photographs of the spectra of Vega, *α* Aquilæ and Venus, and sent a note concerning them to this Journal.

Since that time Dr. Huggins has pursued the subject actively in spite of the London atmosphere, and has attained very fine results, which I had the pleasure of seeing at his observatory last spring. These he is preparing to publish shortly. In my observatory photographs have been taken of the spectrum of Vega, Arcturus, Capella, *α* Aquilæ, Jupiter, Mars, Venus, the Moon, etc. Recently the plan has been to have a comparison solar spectrum on every plate, derived either from the diffused light of our atmosphere or from the Moon or from Jupiter. In this way no difficulty in determining the wave lengths of the lines is encountered, and the changes produced by our atmosphere are eliminated. The telescope and spectroscope are now in good working order, but to secure the requisite degree of precision of movement it has been necessary to make seven different driving clocks before a satisfactory one was attained.

It has been remarked that on account of the faintness of the light of stellar spectra, prolonged exposures of the sensitive plate are required. In former times when the dry processes of photography were much less sensitive than the best wet plates, the exposure was limited by the length of time the plate could be left in the camera without being stained by drying. But now, since the gelatino-bromide process has been introduced, this obstacle has been removed and a sensitive plate is sometimes exposed two hours to the spectrum of a star and then almost an hour to Jupiter for the comparison spectrum. The best, and most sensitive, gelatine plates I have used are those made by Wratten & Wainwright of London; Dr. Huggins was good enough to call my attention to them.

It is not worth while to describe the various forms of spectroscope that have been employed in the last ten years, quartz, Iceland spar, hollow prisms and flint glass have been the materials, and they have been sometimes direct vision and sometimes on the usual angular plan. Gratings on glass and speculum metal given to me by Mr. Rutherfurd have been tried. The length of spectroscope has been sometimes twenty-eight feet and sometimes not as many inches.

The especial spectroscope for stellar work that is now on the telescope is intended to satisfy the following conditions: 1st, to get the greatest practicable dispersion with the least width of spectrum that will permit the lines to be seen; 2nd, to use the entire beam of light collected by the 28-inch reflector or 12-inch achromatic without loss by diaphragms; 3d, to permit the slit to be easily seen so that the star may be adjusted on it; 4th, to avoid flexure or other causes that might change the position of the spectrum on the sensitive plate in pointing the telescope first on one and then on another object; 5th, to admit of observing the spectrum on the sensitive plate at any time during an exposure without risk of shifting or disarrangement. The dispersion is produced by two heavy flint prisms which are devoid of yellow color; the telescopes are about six inches in focal length and the slit has a movable plate in front of it, enabling the operator to uncover either the upper or the lower portion at will.

During the past summer this spectroscope has been used with the Clark refractor of 12 inches aperture, partly because the 28-inch reflector has been kept unsilvered since it was used in taking photographs of the Transit of Mercury, on account of its employment in certain experiments on the Sun. Moreover, there is an advantage possessed by the refractor for this work which does not appear at first sight. Naturally one supposes that a reflector which brings all the rays from the star, no matter what their refrangibility, to a focus in one plane, would be best, because when the slit is put in that plane it is equally illuminated by rays of all refrangibilities, and the spectrum will be parallel-sided in its whole length. On the other hand a refractor is not achromatic, for the violet end of the spectrum comes to a focus either inside or outside of the plane of the rays in the middle of the spectrum, and in observing the spectrum it is not parallel-sided. This peculiarity was used by Mr. Rutherfurd to enable him to correct a telescope lens for the ultra violet rays. It is easy therefore with a refractor so to adjust the position of the slit that you may have a spectrum tolerably wide at F and G, and which gradually diminishes in width toward H, and finally becomes almost linear at M. Now as the effect of atmospheric absorption on

the spectrum increases as you pass from G toward H and above H, by diminishing the width of the spectrum you can in some measure neutralize the effect, and at one exposure obtain a photograph of nearly uniform intensity from end to end, though it is of variable width. If it were not for this it would be necessary to have the spectrum over-exposed at G in order to be visible above H, or else to resort to an elaborate diaphragming which is difficult.

It is my intention next season to return to the use of the 28-inch reflector, because it collects nearly five times as much light as the 12-inch does, after making allowance for the secondary mirror. Of course in a large reflector the difficulties of flexure and instability of the optical axis are much increased, and keeping a star on the slit will be troublesome, especially as the magnifying power on the image is about 50.

As to the results obtained, it has already been mentioned that the spectra of several stars and planets have been photographed. The subject of planetary spectra will be reserved for a future communication. A preliminary examination at once shows that these stellar spectra are divisible into two groups: first, those closely resembling the solar spectrum, and second, those in which there are relatively but few lines, and these of great breadth and intensity. The photographs of the spectra of Arcturus and Capella are so similar to the solar spectrum, that I have not up to the present detected any material differences. But on the other hand, the spectra of Vega and α Aquilæ are totally different, and it is not easy without prolonged study and the assistance of laboratory experiments to interpret the results, and even then it will be necessary to speak with diffidence. I have not as yet obtained any stellar spectrum photographs belonging to the third and fourth groups of stellar spectra as described by Secchi. These, if obtainable, will aid materially in discussing the whole subject, but unless a star passes near the zenith it is hard to make a fair study of its spectrum by photography, because atmospheric absorption in the ultra violet region increases rapidly as the altitude decreases. In the case of the Sun, I have found that at sunset the exposure necessary to photograph the spectrum above H, is often 200 times as long as at midday.

In the case of the spectrum of Vega when examined by the eye, the lines C, F, near G and h, are readily visible, but lines such as D and b are relatively faint. It is clear then, that hydrogen exists to a large extent in the atmosphere of that star. But on examining the photograph of its spectrum it is evident that other lines just as conspicuous as the hydrogen lines, are present. One of these corresponds in position and character to H_1 and seems to coincide with a calcium line. It appears

to me, however, that the evidence of this coincidence is not complete.

In attempting to reason from these photographs as the matter now stands, it is necessary to try at every step farther experiments in order to find out whether the facts agree with hypothesis, and it is this very condition of affairs that gives hopes of results valuable in their bearing on terrestrial chemistry and physics. In the photographs of the spectrum of Vega there are eleven lines, only two of which are certainly accounted for, two more may be calcium, the remaining seven, though bearing a most suspicious resemblance to the hydrogen lines in their general characters, are as yet not identified. It would be worth while to subject hydrogen to a more intense incandescence than any yet attained, to see whether in photographs of its spectrum under those circumstances any trace of these lines, which extend to wave length 3700, could be found.

It is to be hoped that before long we may be able to investigate photographically the spectra of the gaseous nebulæ, for in them the most elementary condition of matter and the simplest spectra are doubtless found.

ART. LI.—*Abstract of Observations upon the Artificial Fertilization of Oyster Eggs, and on the Embryology of the American Oyster;* by W. K. BROOKS, Associate in Biology, Johns Hopkins University. (Notes from the Biological Laboratory of the Johns Hopkins University).

ALL the writers upon the development of the oyster, from Home (Phil. Trans., 1827), to Möbius (Austern und Austernwirtschaft, 1877), state that the eggs are fertilized inside the shell of the parent, and that the young are carried inside the mantle cavity until they are provided with shells of their own: that they leave the parent in a somewhat advanced state of development, and that their free-swimming life is of short duration and lasts only until they find a suitable place to attach themselves.

Misled by these statements, which do not apply to our species, I opened a number of oysters during the summer of 1878, and examined the gills and the contents of the mantle-chambers for young, but found none, and concluded that the time during which the young are carried by the parent must be so short that I had missed it. I undertook the same investigation this May, with the determination to examine adult oysters for young every day during the breeding season, and at the same time to try to raise young for myself by the artificial fertilization of eggs taken from the ovaries. I had complete suc-

cess with the second method from the first, and succeeded in raising countless millions of young oysters, and in tracing them through all their stages of development up to the time when they had acquired all the characteristics which Salensky, Lacaze Duthiers, Möbius and others have figured and described in the young European oyster at the time it leaves its parent. I also made careful examination of the gills and mantles of more than a thousand oysters, but never found a single fertilized egg or embryo inside the mantle-cavity of an adult, although I found females with the ovaries full of ripe eggs, others with the ovaries half empty, others with them almost entirely empty, and others at all the intermediate stages, and I therefore feel sure that my examinations were made upon spawning oysters.

While this evidence is for only one season and one bed, I think that until it is shown to be exceptional, we must conclude that there is an important difference in the breeding habits of American and European oysters, and that the eggs of the American oyster are fertilized outside the body of the parent; that during the period which the European oyster passes inside the mantle-cavity of the parent, the young American oyster swims at large in the open ocean.

The more important points in the development of the oyster are:

1. The oyster is practically unisexual, since at the breeding season each individual contains either eggs or spermatozoa exclusively.

2. Segmentation takes place very rapidly and follows substantially the course described for other Lamellibranchs by Lovén and Flemming.

3. Segmentation is completed in about two hours, and gives rise to a gastrula, with ectoderm, endoderm, digestive cavity and blastopore, and a circlet of cilia or velum. At this stage of development the embryos crowd to the surface of the water and form a dense layer less than a quarter of an inch thick.

4. The blastopore closes up; the endoderm separates entirely from the ectoderm, and the two valves of the shell are formed, separate from each other, at the edges of the furrow formed by the closure of the blastopore.

5. The digestive cavity enlarges, and becomes ciliated, and the mouth pushes in as an invagination of the ectoderm at a point directly opposite that which the blastopore had occupied. The anus makes its appearance close to the mouth.

6. The embryos scatter to various depths, and swim by the action of the cilia of the velum. The shells grow down over the digestive tract and velum, and the embryo assumes a form so similar to various marine lamellibranch embryos which are

captured by the dip net at the surface of the ocean that it is not possible to identify them as oysters without tracing them from the egg. The oldest ones which I succeeded in raising in aquaria were almost exactly like the embryos of Cardium, figured by Lovén.

7. The ovaries of oysters less than 1½ inches in length, and probably not more than one year old, were fertilized with semen from males of the same size, and developed normally.

An illustrated paper on the embryology of the oyster, with a detailed account of my observations, will be published, shortly, in the Report of the Maryland Fish Commission for 1879.

Baltimore, Nov. 5, 1879.

ART. LII.—*Origin of the Læss;* by G. C. BROADHEAD.

WHAT facts Baron von Richthofen may have observed in Eastern Asia tending to form his opinion of the origin of the læss I have not had the opportunity to examine; but from careful observations of the læss in many places along and adjacent to the Missouri and Mississippi rivers, I cannot refer these deposits to æolian or wind-drift agency. Professor Hilgard, in his article in this Journal for August, conveys to us some interesting and correct testimony.

That the læss is stratified in many places I can bear testimony; a notable example may be seen in the bluffs at St. Charles, Mo., near the railroad depot, where it shows finely laminated deposits, made up of planes of differently colored clays and sands, the latter very finely comminuted, showing that at this place the sediment was deposited at different times from very quiet waters. The beds of sand also sometimes appear evidently as if deposited from water. Calcareous concretions are quite characteristic of the læss. They are generally of roundish form, but often elongated, and can sometimes be traced for several hundred feet horizontally, forming beds from a few inches to more than a foot in thickness. The concretions are either united to each other or often separated.

Land snails are occasionally found. Some of the sands are ferruginous, and pipe-stem forms of iron sand are occasionally found, with also hollow root-like forms of calcareous matter. The cohesive strength of the particles tends to preserve the mass in a vertical position for a long time, even at sixty to seventy feet height. When not quite as cohesive, time will wear off the rougher points, and produce rounded mammillated

hills covered with a thin soil, and sloping at about an angle of 50°; for example, the "Mamelles" below St. Charles, and the hills at Glasgow and St. Joseph. Our richest upland soils near the Missouri river are due to a subsoil of loess.

Lastly, the æolian hypothesis is untenable when referred to the loess of the valleys, hillsides, and hills adjacent to the Missouri and Mississippi rivers; for, although often of a depth from twenty to two hundred feet, it cannot be clearly traced far back from these rivers, and I believe in Missouri not farther than fifteen miles from them. It must therefore have been a sediment in the quiet waters when the rivers were blocked up below by ice; when the barrier melted away a channel was worn through the silt, leaving these finely comminuted clays on the neighboring hills as we now find them.

The waters of the Missouri river are full of very minute particles held in suspension. Its waters appear to be whirling continually, the channel is daily changing, sands are deposited on the bars, and fine silt at quiet eddies or in the mouths of the small tributaries, and the latter closely resembles the loess of the neighboring hills. The most if not all of these clays may have originated from the Tertiary and Cretaceous beds of the Upper Missouri.

ART. LIII.—*Observations on the planets Hersilia and Dido;* by Professor C. H. F. PETERS. (From a letter to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., November 8, 1879.)

IN the month of October, two planets were added by me to the group between Mars and Jupiter. I take pleasure in communicating the following observations on their positions. The dates of discovery were respectively Oct. 13 and Oct. 22.

(206) *Hersilia.*

1879.	Ham. Coll. m. t.	App. α.	App. δ.	No. of comp.
Oct. 13.	$14^h\ 35^m\ 52^s$	$1^h\ 0^m\ 36^s{\cdot}63$	$+\ 1°\ 24'\ 52''{\cdot}2$	15
Oct. 14.	10 43 25	0 59 56·51	+ 1 19 54·1	10
Oct. 16.	9 51 24	0 58 23·52	+ 1 9 10·6	9
Oct. 20.	9 46 52	0 55 17·26	+ 0 48 11·1	10

(209) *Dido.*

1879.	Ham. Coll. m. t.	App. α.	App. δ.	No. of comp.
Oct. 22.	$14^h\ —^m\ —^s$	$1^h\ 23^m\ 49^s$	$+13°\ 23'1$	—
Oct. 25.	11 12 36	1 21 32·94	+13 14 27·4	10
Oct. 26.	10 49 55	1 20 47·08	+13 11 20·4	10
Nov. 7.	12 1 6	1 12 12·93	+12 33 1·1	4

The magnitude of Hersilia was 11th; that of Dido about 12th.

ART. LIV.—*On Triple Objectives with complete Color Correction;* by CHARLES S. HASTINGS.

THE prime defect in the large refractors of the present day is the secondary spectrum. This, arising from the irrationality in the spectra produced by the crown and flint glass, hardly noticeable in small apertures, detrimental in telescopes of medium power, is positively obnoxious in the large instruments and will speedily put an end to farther increase in dimensions. On this account there have been many efforts to produce two kinds of glass differing sufficiently in dispersive power, which would still yield mutually rational spectra. As far as I know we are now no nearer success in this direction than when Brewster investigated the subject fifty years ago.

Can we secure the same end by increasing the number of glasses in the objective? Theoretically, since a new disposable constant for color change is introduced with each lens in the system, the answer is evidently affirmative; but if we limit ourselves by the condition that the construction shall be practicable, i. e., that there shall not be too many lenses and the curvatures shall be moderate, the conclusion is not so ready. On entering the discussion we will assume three as the limiting number of lenses and $\frac{1}{15}$ the focal length as the minimum radius of curvature.

The formula for the focal length F of three thin lenses in contact is, if we set $\varphi=\frac{1}{F}$:

$$\varphi=(n'-1)\left(\frac{1}{r_1}+\frac{1}{r_2}\right)+(n''-1)\left(\frac{1}{r_3}+\frac{1}{r_4}\right)+(n'''-1)\left(\frac{1}{r_5}+\frac{1}{r_6}\right),$$

where n', n'', n''' are the indices of refraction for the three materials used, and r_1, r_2, ... r_6, are the radii of curvature for the six surfaces successively. We may write this more concisely for our end, as follows:

$$\varphi=(n'-1)\mathrm{A}+(n''-1)\mathrm{B}+(n'''-1)\mathrm{C},$$

calling A, B and C the *curvature sums* of the first, second and third lens respectively.

The problem then, succinctly stated, is to find values of A, B and C, no one of which shall be more than thirty when $\varphi=1$ and which shall make φ independent of the wave length of light transmitted.

If n can be expressed as a function of any variable x of the form:

$$n=A+Bf_0(x)+\Gamma f_1(x)$$

the problem has its mathematical expression in the equations:

$$\varphi_\lambda=(n_\lambda'-1)\mathrm{A}+(n_\lambda''-1)\mathrm{B}+(n_\lambda'''-1)\mathrm{C}=1$$

$$\frac{d\varphi}{dx}=(B'f_0'(x)+\Gamma'f_1'(x))\mathrm{A}+(B''f_0'(x)+\Gamma''f_1'(x))\mathrm{B}+(B'''f_0'(x)+\Gamma'''f_1'(x))\mathrm{C}=0;$$

but since the latter must hold true for all values of the variable x the final conditions for perfect color correction are:

$$\left.\begin{aligned}(n_\lambda'-1)\mathrm{A}+(n_\lambda''-1)\mathrm{B}+(n_\lambda'''-1)\mathrm{C}&=1\\ B'\mathrm{A}+B''\mathrm{B}+B'''\mathrm{C}&=0\\ \Gamma'\mathrm{A}+\Gamma''\mathrm{C}+\Gamma'''\mathrm{C}&=0\end{aligned}\right\}\qquad(2)$$

the only practical limitation being that neither A, B or C surpass thirty as a maximum.

As to the choice of the variable x, the most natural suggestion is the wave length of light, using the first three terms of Cauchy's well-known formula as an expression for n; but there are two objections to such a course, the first and most important being that three terms of this series will not express the values within the necessary limits of accuracy, and the other lies in the great labor requisite to compute the constants. I have, therefore, chosen to take the value of n for some one material as a standard and compute by the method of least squares the values for other materials as functions of this. The standard selected is Feil's Crown Glass, No. 1219, which I have studied and described, with four other kinds, on page 273 vol. xv, of this Journal. The reason determining the choice is the greater accuracy of our knowledge of its constants over that of any other light glass. The form of the function is a trinomial of the second degree, thus:

$$\mathrm{N}=A+Bn+\Gamma n^2\qquad(3)$$

Doubtless by not restricting it to the first and second powers of n a formula might be shaped which would make the differences between the observed and calculated values less, but as that could be attained only at the expense of much greater labor in determining the various values of the constants, and moreover, as the errors of observation are generally greater than those of the formula, it seems unadvisable to modify it.

In this discussion I have included all the different varieties of glass the optical constants of which I have been able to find given with the requisite accuracy. Unfortunately there are but few. Besides the five which I have determined and are cited above, viz:

Feil's Crown 1219, ----------α
" Flint 1237, ----------β
" Flint 1241, ----------γ
—— Crown A, ----------δ
—— Flint B, ----------ϵ

are included the seven of Fraunhofer,* viz:

Crown 13, ... ζ
Crown 9, ... η
Crown M, ... ϑ
Flint 13, ... ν
Flint 3, ... κ
Flint 30, ... λ
Flint 23, ... μ

six of Van der Willigen† (one closely resembles my A above, while two others are almost exactly alike), viz:

Crown, Merz No. III, ... ν
Crown, Merz No. IV, ... ξ
Flint, Steinheil No. II, ... o
Flint, Merz No. V, ... π
Flint, Hoffmann No. I, ... ρ
Flint, Merz. No II, ... σ

and finally one of Ditscheiner,‡

Flint, ——, ... τ

There are further measurements of 18 different prisms by Dutiron,§ but so inaccurate as to be worthless for our purpose.

In the order in which the glasses are named are entered in table I, the values of the constants for (3).

TABLE I.

	A.	*B.*	*Γ.*
α	+ 0·	+ 1·	+ 0·
β	22·3186075	−29·1759937	10·2399102
γ	14·0097123	−17·9513549	6·4320057
δ	·5679958	+ ·2172063	·2681091
ε	21·026827	−27·430617	9·645678
ζ	·5749543	+ ·2333290	·259890
η	·9025943	− ·2110704	·411148
ϑ	5·2924649	− 6·1318968	2·4193199
ι	19·6074744	−25·7440377	9·1597811
κ	20·7768050	−27·0625275	9·5093547
λ	24·6152640	−32·2820439	11·2916241
μ	25·4950932	−33·4611946	11·688423
ν	2·250818	− 1·973145	0·983738
ξ	2·737385	− 2·679993	1·241673
o	19·541685	−25·438209	8·976709
π	27·444400	−36·035067	12·537277
ρ	43·623628	−57·822556	19·899438
σ	69·141334	−91·827575	31·313410
τ	19·960275	−26·041640	9·196286

* Schumacher's Astronomische Abhandlung für 1823.

† Archives du Musée Teyler.

‡ Sitzungsberichete der k. k Akad. d. Wissenschaften in Wien. Oct., 1864.

§ Comptes Rendus, xxix, pp. 632–636. Poggend. Annal., lxxix, pp. 335–336. Annales de Chimie, xxviii, pp. 176–210. These incredible values, which are extensively quoted in prominent text books on optics, have given me a deal of trouble, used as they are in several places to discuss the defects and possible improvement of the double objective. Only by the merest chance I found on the last leaf of the Annales de Chimie, xxviii, pp. 501, 502, a set of corrections to *all* the values. These new values are less fantastic, but still the errors are large and even indicated anomalous dispersion is not wanting.

If we tabulate the differences between the observed values and those derived by substitution in the formula, we have the following expressed in units of the sixth place:

TABLE II.

$n-N.$

	A	B	C	D	λ 5614	E	F	λ 4548	G	h	H
a	0	0	0	0	0	0	0	0	0	0	0
β	+26	− 4	−12	−31	− 6	+ 3	+23	+ 4	+12	− 4	−10
γ	+24	−10	−10	−21	− 4	+ 6	+19	+ 4	+ 4	− 1	− 7
δ	− 9	− 0	+ 2	− 1	+15	+15	−14	—	−20	0	+12
ϵ	+ 8	− 8	− 3	−10	+ 4	+13	+ 5	—	−10	− 9	+12
ζ	—	+ 2	+ 4	− 1	—	+ 4	−11	—	− 4	—	+ 3
η	—	−15	+ 4	+16	—	− 3	+17	—	−34	—	+16
ϑ	—	+ 4	+ 8	−25	—	+10	+ 6	—	− 2	—	− 1
ι	—	− 2	− 7	−21	—	+36	+15	—	−24	—	+ 2
κ	—	−42	+29	+35	—	−11	−20	—	+ 5	—	+ 2
λ	—	− 1	+45	−27	—	+ 7	− 7	—	+19	—	−36
μ	—	+19	+10	−34	—	−30	+24	—	+30	—	−19
ν	+23	+19	−22	−42	—	+14	+20	—	+13	+19	
ξ	+21	− 3	−16	−15	—	+15	+11	—	−10	+22	
o	+38	−27	−13	−25	—	+ 2	+28	—	+15	−19	
π	+54	−16	−37	−34	—	− 9	+28	—	+29	+17	
ρ	+40	−19	−30	−19	—	+11	+25	—	+ 4	−11	
σ	−60	−47	−26	+25	—	+119	+116	—	−32	−92	
τ		− 8	+26	−10	−34	− 0	+43	—	+ 8	−26	

The systematic distribution of the differences in the first group shows, not only the short-coming of the formula, but also that the extreme accuracy, indicated by the probable errors attached to the indices, is not imaginary.

The accuracy of the second group is also great but much inferior to the first. Occasional abrupt changes as in that of ϵD to ϵE in table II can only arise from erroneous values in the indices. Here we recognize at once that n_E must be about thirty too great.

The indices of the following groups are only given to five places of decimals and are evidently made with much less care than the others.

By taking from table I the constants for any three glasses and substituting them in formulas (2), we obtain values of A, B and C, which would give complete color correction, but in general the values would not be all below thirty, the limiting maximum. Of those, however, which satisfy this condition, I select four cases, confining myself to these four, not because it exhausts all the serviceable combinations or even gives the smallest values for the curvature sums, but because it introduces eight out of the nineteen glasses which are most useful. They are:

Case I.	α	β	ι
" II.	ν	π	o
" III.	ν	π	τ
" IV.	ξ	π	o

giving values for the curvature sums:

	A.	B.	C.
I.	3·47026	7·20807	− 8·35472
II.	9·47513	14·28004	−21·23665
III.	7·58585	11·57425	−16·59076
IV.	11·67459	18·10299	−27·22301.

Substituting these values in the general formula (1) we derive for F the following, the first column giving the Fraunhofer ray for which the focal length is computed:

TABLE III.

	I.	II.	III.	IV.
A	———	1·00002	———	1·00000
B	1·00000	·99949	·99989	·99968
C	·99999	1·00043	1·00102	1·00053
D	·99999	1·00026	1·00052	1·00005
E	1·00024	·99992	·99942	·99993
F	·99999	·99988	·99951	·99999
G	·99999	1·00002	1·00030	1·00000

To exhibit more distinctly the improvement in this form over the double objective, I arrange the differences in the above values between each and the true focal length of that system in a table, supplementing it with a sixth column in which are entered the corresponding differences for a double objective of glasses α and β with its best color correction, and having a focal length of unity.

TABLE IV.

	I.	II.	III.	IV.	V.
A	—	+ 2	—	− 3	+135
B	+ 1	−53	−22	−35	+ 66
C	0	+41	+91	+50	+ 41
D	0	+28	+41	+ 2	+ 0
E	+25	−10	−67	−10	+ 13
F	0	−14	−60	− 4	+ 73
G	0	+ 2	+21	− 3	+287

The large difference in F_E is owing to an erroneous value of n_E in Fraunhofer's Flint 13.

The greater differences in the other cases are to be attributed to inaccurate measurements of the optical constants, inaccuracies which are most marked in Ditscheiner's determinations. It may be noted that only in the first two groups are the indices given to six places of decimals, and whatever the errors may be they are multiplied by large factors in all but the first case. That these differences do not represent any outstanding color we may be sure from their non-systematic character.

The problem is then solved generally and shown to be quite practicable in the case of a number of known varieties of glass.

Of course in its practical application this process should be used to yield a first approximation only, since the thicknesses and distances of the lenses are neglected; but having this there is no difficulty, other than the laborious character of the computations involved, in determining by successive approximations the values of all the radii requisite to secure complete color correction and at the same time eliminate spherical aberration. As in the case of a double objective, after satisfying the conditions of given focal length, of color correction, and elimination of spherical aberration, we have one arbitrary condition to impose, so in a triple objective we have two arbitrary conditions to impose. In my opinion, were we using materials that required large curvature sums, it would be advantageous to utilize these two conditions in making two of the lenses respectively biconvex and biconcave, thus rendering the necessary thickness of the materials a minimum.

These results are directly opposed to those of a recent writer in this Journal.* But his conclusions arise from erroneous calculation. Not only does his interpretation of his equation (12) imply the manifest absurdity that in a system of infinitely thin lenses in contact its properties are determined by the order of the lenses, but the interpretation is impossible. True A_3 should have an opposite sign to A_1+A_2, but that asserts nothing as to likeness of the latter symbols in sign. Thus n in equation (16) may be negative and consequently his subsequent reasoning is fallacious, for in that case n does not have to be infinite to cause equation (27) to vanish. I may add that the origin of the confusion is in making the ratio $\frac{D}{E}$ in equation (9) constant; it may be, and if course should be, indeterminate.

Professor Harkness has made another mistake, founded upon inadequate experiment, which has so important a bearing on the theory of the double objective that it should not be allowed to pass uncorrected. His statement (p. 191) concerning the condition for color correction, is substantially correct, though, in my opinion, it is not self-evident but requires proof. This proof I shall supply in a forthcoming number of the American Journal of Mathematics. His experiment, however, (p. 193) directly contravenes this principle, for he finds that the focal plane does not correspond to the minimum focal distance, but to something greater. The source of error is the introduction of a variable element in the system, namely, the eye, which would adjust itself differently in observing the star and its spectrum. Had the writer used eye-pieces of successively higher power,

* Professor Harkness, in the September number, pp. 191–193.

thus lessening progressively the power of accommodation of the system, with his prism, he would have seen his points γ_m and γ_n approach until they sensibly coincided; or better still, had he formed his spectrum by a grating (such as perforated cardboard) before the objective, instead of by a prism between the ocular and eye, he could not have been misled, since the uncolored image would serve to control the eye.

Finally, the fourth conclusion (p. 196) is strictly true, though we are not to conclude, as would seem from the text, that the detriment due to the secondary spectrum depends either solely upon the aperture or varies inversely as the focal length; for, though the secondary spectrum remains constant in dimension with a given aperture and consequently its angular value decreases inversely as the focus, a stellar image (diffraction disk,) increases directly as the focal length. Hence by increasing this element more of the central portion of the secondary spectrum, i. e. the brighter portion, would be absorbed into the stellar disk. In other words, by doubling the length of the telescope the secondary spectrum becomes much less than half as offensive.

Johns Hopkins University, Sept. 20th, 1879.

ART. LV.—*Geology of Virginia:—Balcony Falls. The Blue Ridge and its geological connections. Some theoretical considerations;* by J. L. CAMPBELL, Washington and Lee University.

AMONG the many localities in the mountains of Virginia that are peculiarly interesting to the geologist, very few offer attractions superior to those found in the great natural section of the Blue Ridge at Balcony Falls, where the James River passes from the Valley to Piedmont Virginia. The canal from Lynchburg to Lexington passes through this mountain gorge, and renders the exposures of the rocky formations easily accessible. Here both the Archæan and the Primordial formations are displayed in their relative positions, and their contact laid bare to inspection. Reference was made to this point in a former paper (July No. of this Journal, pp. 22, 23), by way of illustration. I now propose to discuss some of its interesting features more in detail.

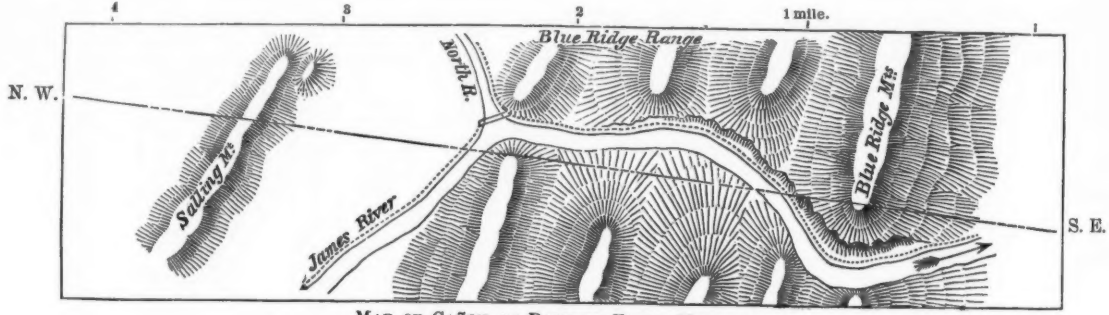
Topography.—The accompanying map and section will serve to throw light upon both the topographical and the geological features of the locality. Leaving out of view a number of irregular foot-ridges on the southeast side, we may regard the

range of mountains here, known as the "Blue Ridge Range," to consist of, (1) the real Blue Ridge on the southeast border—the long water-shed between the valley and Piedmont Counties—between Rockbridge on the northwest and Amherst and Bedford on the southeast. Here and for some miles along its line both ways, this ridge is flanked by Archæan rocks on the southeast and Primordial rocks on the northwest—the latter resting unconformably upon the former. (2) Skirting the northwest side of this leading ridge, and parallel with it, are two well defined lines of broken ridges that have evidently been once continuous, but now consist of short, abruptly terminating mountains, of rounded dome-like hills, and of rugged conical peaks. These all have a frame-work of Primordial sandstones, with the less durable shales of the same period lying along their flanks or filling the depressions between them. Of these lines of ridges the one bordering on the great limestone valley, heretofore described, (see July No.), is by far the most conspicuous, and the most uniform in its physical features. It consists essentially of the durable masses of the Upper Potsdam sandstones, so durable that many parts of it have maintained a height almost equal to that of the main ridge, the average height of which, in this region, somewhat exceeds 2500 feet. The mean bearing of this portion of the range is about N. 35° E.

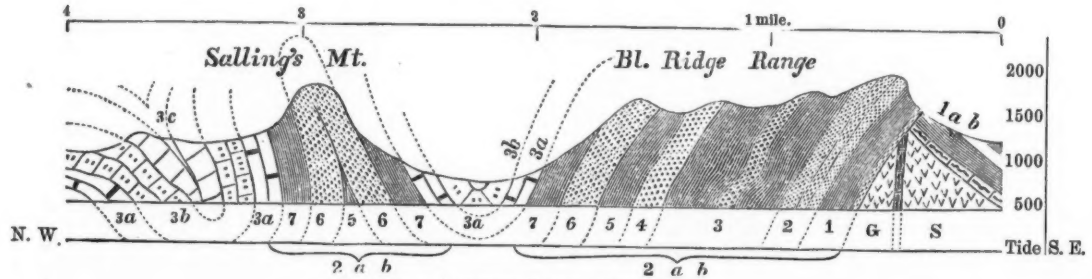
Salling's Mountain, seen on the left of the map, is an outlying ridge of Primordial sandstones and slates, cut off at its northeastern end by the North River, and at its southwestern end by James River. It is separated from the principal chain by a narrow synclinal valley of limestone (Lower Silurian), most of which is concealed from view by an extensive bed of *alluvium*, accumulated by the two rivers that meet here; but accumulated originally in a Y-shaped lake, through which they seem to have flowed at some former period of their history.

The two rivers above mentioned, traverse the little valley obliquely, and meet at a very obtuse angle just where their waters, as one united stream, enter the deep gorge or cañon by which they pass through the mountain range. Just below their junction are mills for grinding hydraulic lime burnt from the ledges that crop out a little higher up the James River. "Balcony Falls" is the name given to a succession of "rapids," beginning about half-a-mile below the Cement Mills, and continuing to the southeast limit of the gorge. The river here is 700 feet above tide level.

Geology.—The foregoing outline of the topography of the region will enable the reader to understand more clearly its geological peculiarities, and to interpret more readily than he otherwise could, the ideal section accompanying the map.



MAP OF CAÑON AT BALCONY FALLS, VIRGINIA.



SECTION AT BALCONY FALLS, JAMES RIVER.

Conceive a vertical plane with its edge resting on a line represented by the broken line of the map, marked "S.E.," and "N.W.," and having a height of 1500 feet above the bed of the river. Then imagine all the outcropping faces and edges of all the eroded rocks of the gorge, and all that the plane itself would cut (including those of Salling's Mountain), to be pictured on the plane, and you will have a mental conception of what the section is designed to represent.

The student of geology will find here a somewhat intricate, but a very interesting problem for solution. By a series of careful observations along the canal and bed of the river, and also by the turnpike that crosses the mountain near the canal, very satisfactory conclusions may be reached. In the gorge we have the rocks of two distinct eras so meeting as to enable us to study not only their composition and structure, but also their relative positions, and some of the metamorphic influences they have exerted upon one another. These two eras are, (1) the Archæan, represented on the accompanying section by the rocks on the right marked G, S, and 1 *a*, *b*; (2) a portion of the Lower Silurian covering the remainder of the section.

Let us begin at the base of the Archæan. Here we find two masses, or a sort of double mass, marked G. and S.—the former a mass of Granulite, and the latter of Syenite. These are usually regarded as igneous, or perhaps with more propriety, aqueo-igneous rocks. They underlie the stratified rocks of this era; but, considered as solid rocky masses, they are probably of more recent date than any other rocks represented on the section—having been thrust upward beneath the over-lying stratified beds in a plastic (semi-fused) condition, and subsequently hardened into their present condition.

G. is "granulite"*—a granitoid rock, eruptive in its origin. It is composed of granular quartz mixed with feldspar, both white and pale flesh-colored; and has numerous crystals of garnet, and occasional crystals and blotches of epidote disseminated through it, giving it a spotted appearance. This is about 100 feet wide at the base, and seems to be separated from the larger mass of syenite (S.) by a crushed and greatly metamorphosed bed of gneissoid rock, in which distinct traces of the original bedding can be seen. The syenite is well exposed from a short distance below the limit of the granulite, as far down the canal as to lock No. 15. It also forms a rugged bed for the river in this part of its course, and rises to the height of several hundred feet beneath the mountain on the opposite side. Syenite is a granitoid rock composed essentially of quartz, feldspar and hornblende, in varying proportions.

* So classed by Professor Dana, to whom a specimen was submitted.

Besides these constituents we find the mass at Balcony Falls containing, in some places, considerable quantities of epidote, both crystalline and amorphous, giving the rock a green color, and in others numerous crystals of garnet.

The bedded rocks (1, *a*, *b*,) that rest upon the syenite, are very much metamorphosed, are gneissoid in character, and dip toward the southeast. These are succeeded by beds of red and brown slates. Then follows a bed of forty or fifty feet of conglomerate quartzite, bearing some resemblance to the conglomerate sandstones on the opposite side of the ridge, but so unlike in composition, texture, position and thickness as to preclude the idea that they have any historical connection. Over this again we find another bed of slate. These beds all dip towards the southeast, while their upper margins reach beyond the underlying syenite and granulite, and with their edges support the lowest beds of Primordial rocks where they extend high up on the ridges, beyond the limit of the igneous beds. The two series here, and at other points along the ridge, are entirely unconformable. Such are the Archæan rocks.

Starting again on the northwest side of the granulite, let us briefly sketch the remarkable beds that make up the remainder of this massive range. In the Archæan rocks we have just described there are no traces of fossil remains, nor do we find any in the lowest beds of what we call Primordial. If organic remains have ever been imbedded in them here, they have either been obliterated or remain yet to be discovered.

Subdivisions.—On the section illustrating a former article (July No.), the classification of Professor Rogers in his reports was employed, and subdivisions of my own introduced. In a second article (August No.), the classification and notations* of Professor Dana's Manual were introduced. This latter system I shall employ in this paper—introducing subdivisions only in the Primal period, numbered, 1, 2, 3, etc.

The Primal or Potsdam period is often divided into Acadian and Potsdam epochs—2*a* and 2*b*—but as it is very doubtful whether both of these, as they occur farther north, have equivalents here, or if they have, where the horizon between them is to be found, I shall designate the whole period as 2*a*, *b*, and its subdivisions 1, 2, 3, 4, etc. These will correspond with the subdivisions, 1*a*, 1*b*, 1*c*, etc., on my former section. As these were then regarded as only of secondary importance to my main object—the Silurian limestones—a very brief description of them was deemed sufficient; but now they become of prime importance in our discussion, and demand a more full and detailed examination.

* Professor Rogers himself has partially adopted this system in his article on the Geology of Virginia, in Macfarlane's Geol. R. R. Guide.

Without repeating in each case the notation, 2*ab*, the several subdivisions will be referred to by the simple numbers, 1, 2, 3, etc. All the beds of this period, with some local and limited exceptions, dip toward the northwest. The slight alternations and variations of dip are confined almost entirely to the thinner beds of sandstone, and the shales contiguous to them (especially in 3), and are limited apparently to points near the margin of the river. Variations in the steepness of dip in the heavy beds of sandstone as they rise toward the crests of the ridges, are, however, common throughout the whole range. The limited irregularities may, with much plausibility, be referred to the undermining action of the river; for there are abundant indications that the water once stood several hundred feet higher in this pass, and in the little valley west of its entrance, than the present height of the river bed.

Subdivision 1 is a bed of conglomerate about fifty feet thick, resting unconformably against the Archæan rocks, and composed of sand, rounded quartz pebbles, fragments and worn crystals of feldspar, with some fragments of epidote, all firmly cemented together, and hardened by the action of heat from the contiguous igneous rocks; followed by several alternations of slates and conglomeritic sandstones, with an aggregate thickness of about 120 feet. This division has been considerably affected by heat throughout. Its position, too, has protected it against the erosive action of the river which has been far less here than it has been among the slates higher up in the series.

Number 2 is a heavy mass of sandstone fully 350 feet thick, and so hard that we may call it "quartzite." It consists of three tolerably distinct beds varying in hardness and color; the lowest being very hard and of a light gray, sometimes pinkish color; the middle one of coarser texture, partly conglomerate and mostly of a greenish gray color; the upper bed is more brittle than either of the other two, and of darker color. These heavy beds of hard sandstone seem to have presented one of the most durable barriers to the passage of the river through the mountain, and doubtless obstructed its flow to such an extent as to keep the water in contact with the higher beds for a period long enough to cause some modifications already mentioned, and others to be noticed hereafter. Before the canal was constructed the steep rugged outcrop of this massive ledge projected considerably over the left margin of the river, and was known as "Balcony Rock"—hence the name of the falls. For some little distance on the west side of this sandstone the river runs nearly with the strike of the strata, exposing in succession the rugged edges of the several beds.

Number 3 consists of two heavy beds of slates separated by a stratum of hard conglomeritic sandstone about sixty feet

thick, and greenish gray color. The slates are of brown, purple and yellow colors, with some thin beds of argillaceous sandstones interstratified. At this point the river has left some marked traces of its former action in eroding the softer, and undermining the harder strata. The most conspicuous irregularity has been caused by the undermining of the interstratified bed of sandstone just mentioned, so as to give it a low, and sometimes waving dip, and to cause a mass of it to slip from its normal position and modify both dip and strike, as seen just above the margin of the canal. This seems to me the only rational way of accounting for the anomalous position of this bed of sandstone at this point, compared with its position at several other points remote from the river. It also explains its want of conformity with the general structure of the whole Primal period, as exhibited all along this part of the Blue Ridge range. These local irregularities are not represented on the section.

It is a little difficult to determine, even approximately, the thickness of this double bed of slates with its enclosed sandstone, but the aggregate must be at least six hundred feet.

Number 4 is not well defined below, since 3 becomes more and more siliceous and blends gradually into it; but the greater part of it is a bed of brownish gray sandstone with a well defined upper surface. It crosses the river at the Cement Mills, and its highest ledge forms the abutment of the dam on the opposite side of the river. Where a deep channel was washed out by a freshet a few years ago, this rock is well exposed on the lower margin of the turnpike, and its upturned edges may be conveniently examined. A considerable exposure of it also crops out above the turnpike between the houses of Messrs. Locker and Campbell, while the corresponding ledge may be seen on the cliff beyond the river. It has a very regularly jointed structure—the cleavage planes being so distinct as to have been mistaken by an unpracticed observer for planes of stratification dipping to the southeast, while the true planes of stratification dip with considerable uniformity and great constancy toward the N.W.

In this and some of the lower beds of sandstone, very faint impressions of fucoids and occasional Scolithus borings are found; but the conglomerate structure is much less prominent here than in the older beds.

Number 5 is made up of numerous thin beds of slate quite different in color and texture from any that we find lower down. They exhibit, where recently exposed in repairing the canal, a great variety of color from nearly pure white kaolin to various shades of yellow, red and brown, and abound in fine scales of mica; but no distinct traces of fossil remains have

been found in them. In the portion near the river their dip varies from 25° to 50°. I estimate their thickness at 180 feet.

Number 6 is, in some respects, the most interesting of all the subdivisions of this Primal group. It is the sandstone that "constitutes the type of this formation." It differs from the beds already described in both its lithological and fossil peculiarities, (see July No., p. 22). It may well be called the "Scolithus sandstone," if we call the primal worms (?) that had their millions of habitations in this rock the "*Scolithus linearis.*"

Its entire thickness (including some quite brittle beds that underlie and overlie the more massive portion), is about 340 feet. The dip at the base of the ridge, where the two rivers meet at the entrance of the gorge, is fully 65°, while it falls gradually to 40° before it reaches the summit—looking as if it might once have been one leg of a grand natural arch, which still stands up with one exposed face forming an almost perpendicular cliff nearly 800 feet in height. There is, however, no point in this portion of the range where I have found it reaching beyond the northwestern line of ridges, of which it generally forms the crest and the greater part of the western slope, as represented on the accompanying section. A part of this sandstone, with the next beds of slate and sandstone below it, has broken loose from the upper outcrop of the ledges on the S.W. side of the river, and slipped down the eastern face of the ridge without any great change of dip. This displaced mass may be seen as a very conspicuous object nearly opposite, though a little below the Cement Mills. It is apparently one of the effects of undermining by high water in the remote past.

Division 7—the upper Potsdam shale—usually extends some distance up the slope of 6, where the normal dip has been preserved, as may be seen at the iron mines a short distance to the N.E., or opposite the Cement quarries, a short distance S.W. of the entrance of the gorge; but just at the entrance it has been eroded by the river and then concealed very much from view by the drift and diluvium of the valley. Its dip increases toward the valley. As nearly as can be determined here, the thickness is fully 600 feet. A sufficient additional description of it may be found in the July number, p. 23. This brings us to the top of the Primordial period.

The next is the Canadian Period (3)—sometimes called, "Middle Cambrian"—and, like the Primordial, belongs to the Lower Silurian Age. It has three epochs, Calciferous (3*a*), Quebec (3*b*) and Chazy (3*c*). The first of these, named from the prominent character of its rocks in New York, might well be called "Hydraulic," in Virginia, as it is generally characterized by the presence of one or more beds of hydraulic limestone. Where our section crosses, this limestone is quarried

from a bed twelve or thirteen feet thick, interstratified with shales and other beds of impure limestone. It dips steeply to the northwest, and again crops out at the base of Salling's Mountain, on the west side of the little valley in which the two rivers meet. Over it lies a part of the Quebec (3*b*), that has escaped the denuding agencies that have operated so extensively over the whole of the Great Valley. It crops out at a number of points along the James River near the cement quarries, and along the base of Salling's Mountain. We have thus a synclinal trough of limestone resting upon the Primordial shales and sandstones, which we find rising again on the west side and forming the mass of the bordering mountain.

In a depression of Salling's Mountain, about half-a-mile to the right of the point cut by the section, and where the turnpike leading from Balcony Falls to the Natural Bridge crosses, we find the shales and thin beds of sandstone of 2*ab*, 7, extending to the top of the ridge, but where the mountain is more elevated, the heavy beds of Scolithus sandstones (2*ab*, 6), form the core of the ridge, all dipping steeply to the southeast: while beyond, the mountain shales of 7 again appear, dipping toward the mountain and apparently beneath the sandstone which elsewhere underlies them. Then as we descend into the valley beyond the mountain we again meet with the limestones and interstratified shales of 3*a* and 3*b*, dipping under 7. These facts lead to the conclusion that the mountain is a closed fold of Primordial strata pushed over toward the northwest, so as to invert all the strata on that side, and place the older above the newer. But on crossing a low ridge half-a-mile from the mountain and parallel with it, the limestones appear again on its western side still dipping southeast, but in their normal order. From an examination of this limestone ridge at different points, the conclusion to which my mind is drawn is, that it consists of a closed synclinal fold, the middle portion of which is the lower part of the Chazy (3*c*), all higher beds having been pressed out and subsequently swept off. This part of the section will be readily understood from simple inspection.

Salling's Mountain will serve as a type of a considerable number of nearly parallel outliers of the main Blue Ridge chain, extending for thirty miles toward the southwest; and consisting of arches of the upper Primordial strata of sandstones and slates, as may be seen on the road leading from Buchanan to the Peaks of Otter, or of closed and inverted folds, a conspicuous example of which may be found in the ridge that separates Buford's Valley in Bedford from the Great Valley in Botetourt County, and is here called Blue Ridge, because it is the geographical watershed between the two counties—not because it is a continuation of that ridge geologically.

Ridges of this class generally lie off from one to several miles from the main range, and seem to have been thrust up beneath the limestones of the Canadian Period, the folds of which were probably much shattered at the time, and subsequently worn or swept away, so as to leave the ridges of more durable sandstone naked for some distance down their steep sides, and flanked along both bases by slates and limestones—the latter often occupying narrow valleys or troughs, like the one above described, or like Buford's Valley in Bedford county, traversed by the A. M. and O. R. R., in going from Lynchburg to Salem.

Theoretical considerations.—1. The Primal strata, as well as all those of later date, given on my two former sections, (July and August Nos.), are of oceanic origin, and the sandstones and conglomerates have evidently been deposited over the bottom of shallow water, and most heavily along the margin of an ancient ocean whose shore-line was the Blue Ridge. The earliest of these beds—those found at the very bottom, and for some distance upward in the series, are composed of the debris of still older rocks that composed the ancient shore land, and that seem to have been metamorphosed before they were worn down as material for the Primordial strata; for in the latter we find fragments of metamorphosed slate, with both fragments and crystals of feldspar, epidote, etc., more or less water-worn, mingled and cemented together, but not otherwise differing from the same material, as we now find it broken down by the weather from the metamorphic rocks of the Archæan land.

2. The irregular, unbedded masses of syenite and granulite that constitute the base of the Blue Ridge, have evidently been erupted since the deposition of the Primordial strata. This is evident from the mode of contact of the two classes of rock—the stratified resting at a high dip against the igneous masses; and also from the influence the heat of the igneous rocks has exerted upon the slates and sandstones overlying them. Again, the higher we ascend in the series the fewer traces we find of the metamorphic changes.

3. As far as we can read the records left upon the Silurian rocks from the Primordial upward, mechanical force seems to be entirely inadequate alone, without the aid of heat from other sources, to produce any very great amount of metamorphism. The extent to which the rocks represented on the several sections I have given—especially on the first—have been subjected to bending and pressure, and consequent friction, ought, according to the mechanical theory of metamorphism, to have made the Great Valley of Virginia one vast mass of metamorphic strata. But no such effect has followed. The limestones have their fossils beautifully preserved. The sandstones have

not been changed to quartzite. The shales are still nothing but fragile shales (with a few exceptions); while the embedded limonite iron ores still retain their water of crystallization. There has been metamorphism, but only limited, not general, except so far as it has been produced through other agencies than heat, or even super-heated water under pressure.

4. Such closed folds as we find in Salling's Mountain, and in many localities among the lower Silurian limestones, seem to have been great wrinkles in the strata, pushed upward (or downward in the case of synclines), and then pressed together by mechanical force acting from a southeasterly direction and in a horizontal plane. This is the only way we can plausibly account for the numerous troughs and arches and folds found along the lines of the several sections we have had under discussion.

5. The flexures and folds of course produced numerous fractures, especially in the limestone beds, and thus prepared the way for the action of the denuding agencies that stripped this great limestone valley of thousands of feet of its original covering. As the pressure was most powerful on the margin nearest the Blue Ridge, so we should expect to find there the flattest folds and the most numerous fractures, and consequently the greatest amount of denudation. Such we find to be the case; for in the first place, we find the higher—the Trenton—limestones from the James to the Potomac nearly all gone from that side of the valley; and in the second place, all the waters in this region flow toward that side, until they approach the base of the mountain near which they continue till they find an outlet by some one of the great streams that carry them through the mountains and finally to the Atlantic Ocean.

Water acting alone could hardly have been the cause of the vast amount, and peculiar kind of denudation we find extending over nearly the whole 6,000 square miles of this limestone valley, unless it had swept over it in one vast torrent sufficiently deep and powerful to have carried whole mountain chains before it. A much more probable hypothesis is that ice as well as water was an important agent in bringing about the great changes of surface that have given this valley its wonderful fertility.

There are indications throughout this whole region of two great flood periods, since the close of Paleozoic time, when the great Appalachian revolution left the vast accumulations of stratified rocks of that remote age in essentially the same relative position they now occupy. But further notice of these must be postponed for the present.

ART. LVI.—*On the Character and Intensity of the Rays emitted by Glowing Platinum;* by E. L. NICHOLS, Ph.D. (Göttingen.)

IN 1860, Kirchhoff* issued his well-known paper on the relation between the capacity of bodies for emitting and for absorbing rays. That essay made a new epoch in the science of Radiation. It offered the first complete proof and the first universal expression of a principle which had existed in the minds of scientists, more or less dimly, since the days of Euler.†

Although the results of that treatise have been repeatedly confirmed by the experience of investigators in Optical Science and in the domain of Radiant Heat, there have been, so far as I know, in spite of the interesting character of Kirchhoff's Function I,‡ no attempts to measure its values.

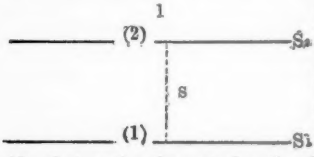
* Kirchhoff, Poggendorff's Annalen, cix; also, "Untersuchungen über das Sonnenspectrum—Anhang."

† For earlier attempts to express what is now known as Kirchhoff's Law, see Euler, Opuscula Varii Argumenti, Berol. 1746 (Nova Theoria Lucis et Colorum, Cap. V). Pierre Prevost, Physische-mechanische Untersuchungen über die Wärme, Halle, 1798. Ångstrom, Poggendorff's Annalen, xciv. Balfour Stewart, Proceedings of the Royal Society of Edinburgh, 1857–58.

‡ In the above-mentioned treatise Kirchhoff gives for I the following formula:

$$e = I\frac{w_1 w_2}{s^2}$$

where (fig. 1) w_1 and w_2 are the projections of the openings (1) and (2) in the screens S_1 and S_2, upon planes perpendicular to the axis of a pencil of rays, which, going out from the black body C, passes through both of these openings: where further, s is the distance between the two openings, and e the emissive capacity of a black body. A black body according to Kirchhoff, and the same definition applies to the term when used in this paper, is a body which even when of infinitesimal thickness absorbs all the rays falling upon it. The following short extract from Kirchhoff's paper will serve to define clearly what is to be understood by the terms *emissive capacity*, *absorptive capacity*, etc.



"Before a body C (fig. 1) let us suppose two screens S_1 and S_2 to be placed, in which are the openings (1) and (2), of infinitesimal size when compared with the distance between them, and of such shape that each of them may be said to have a center. Suppose the body C to send out a pencil of rays through these two openings. Of this pencil of rays let us consider that portion the wave lengths of which lie between λ and $\lambda + d\lambda$, and let us imagine the same resolved into two components, polarized in the planes a and b.

Let the planes a and b pass through the axis of the pencil of rays, and let them be perpendicular to one another. Let, further, $Ed\lambda$ be the intensity of the component a, or, what amounts to the same thing, the increase which the kinetic energy (lebendige Kraft) of the ether behind the screen S_2 suffers in a unit of time by the action of this component. The quantity E is called the *emissive capacity of the body.*" (§2 of Kirchhoff's treatise.)

"Suppose the body C to be black. For its emissive capacity, which in general will be denoted by E, we shall substitute e." (§4.)

In the case where for the black body a body of any other kind is substituted, the equation becomes:

I.

It is the purpose of this paper to describe a series of such researches, made in the Physical laboratory of Professor Helmholtz, at Berlin.

The quantity I is (see preceding foot-note) a function of the wave lengths of the ray and the temperature of the radiating body. Its study, therefore, involves the measurement of the intensity of all wave lengths emitted by the source of light in question, at all temperatures for which the rays are of perceptible energy.

The nature of the subject demands different methods of investigation for the study of the visible and of the invisible rays. The measurements to be described in this paper are confined to the visible rays, and the lowest temperature under consideration is that at which bodies begin to glow.

Two platinum wires 100^{mm} long and about $0{\cdot}4^{mm}$ in thickness, served as sources of radiation. Each formed part of a powerful galvanic circuit, in which the current was produced by a Bunsen's battery. The resistance of each circuit could be varied by introducing or withdrawing copper wire, after the principle of the Wheatstone's bridge. One of these bridges served to compensate for the gradual weakening of the battery, so that the glowing platinum could be maintained at a constant temperature. In the other circuit the platinum wire could be given, by means of the bridge, every temperature from a red heat to the melting point.

It being desired to keep the wire in the first circuit at a constant temperature, a delicate mirror galvanometer was adjusted in this circuit, by means of a very weak branch current. This instrument, when carefully compensated with a bar magnet, showed by the motion of a spot of light upon a screen, two and a half meters distant, every change in the intensity of the current and, of course, in the temperature of the wire. The galvanometer, when properly adjusted, was sufficiently delicate to show unmistakably very much smaller changes of temperature than could be detected either by observing with the eye changes of color in the wire, or by studying with any known instrument the changes in the character of the light emitted. Quite as essential to success as the constant temperature of the wires during a single experiment, is the ability to reproduce in the wires, after interruption of the circuits, exactly their former temperatures.

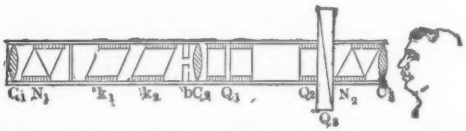
$$\frac{E}{A} = I\frac{w_1 w_2}{s^2}.$$

Here A denotes the ratio of the intensity of rays absorbed by the body to the whole intensity of the rays falling upon it. In other words, A is the *capacity of absorption* of the body.

To lessen the chances of error I used, in addition to the galvanometer, Kitao's* "Leucoscope," an instrument† admirably adapted for showing qualitative differences in the character of heterogeneous rays. I used the original instrument described in Kitao's treatise. The leucoscope is essentially a polarizer, resembling in some respects Soleil's saccharometer.

"N_1 N_2 (fig. 2) are two Nicol's prisms, k_1 k_2 denote two

2.



exactly similar rhombohedra of calcareous spar, g is a plate of mica, thin enough to show colors of the first order, b is a slit, the width of which can be altered at pleasure by means of an appropriate adjustment. Q_1 Q_2 are two quartz plates, cut perpendicularly to the optical axis. Q_3 denotes two wedge-shaped quartz plates also cut perpendicularly to the axis. These plates turn the plane of polarization in the opposite direction from Q_1 Q_2. C_1 C_2 C_3 are lenses, the focal distances of which are such as to give a sharp enlarged image of the slit, and of distant objects, the images of which are cast upon the slit by the lens C_1. These parts are set in a tube, blackened on the inside to exclude all foreign and useless light." Light entering the instrument is polarized at N_1, split into two rays by the rhombohedra, so as to form a double image of the slit b. As the observer rotates the ocular Nicol N_2, the action of the mica lamina and of the quartz plates gives to the two halves of the double image different tints, alternating between red and green. Whatever be the character of the ray, a thickness of quartz can be found such that at four positions of the ocular Nicol, distant 90° from one another, the two halves assume the same neutral tint. Kitao calls this the point of maximum paleness. This thickness of the quartz plates varies with the composition of the ray, and a means is thus afforded of detecting minute qualitative differences in its light. When the experimenter, having adjusted the instrument for a particular kind of heterogeneous light, turns—without changing the quartz plate—to the observation of rays which differ from those of the first source, he finds that the position of the ocular Nicol corresponding to the maximum of paleness differs for each new kind of light.

A series of experiments were made to test the adaptability

* Diro Kitao, "Zur Farbenlehre, Inaugural-dissertation, Göttingen, 1878.

† For a full description of this interesting apparatus, which being a new invention is not so widely known as it deserves to be, I must refer for lack of space to Kitao's paper.

of the leucoscope to this purpose. Its sensitiveness is best shown by the final test, the comparison of two parts of the same petroleum flame. These portions, a cooler and a warmer, were so similar in color that with the unaided eye no difference could be detected. The mean of twenty observations with the leucoscope gave for the position of the ocular Nicol,

TABLE I.

For the upper part of the flame	64° 4′
For the lower part of the flame	62 16
Difference	1 48

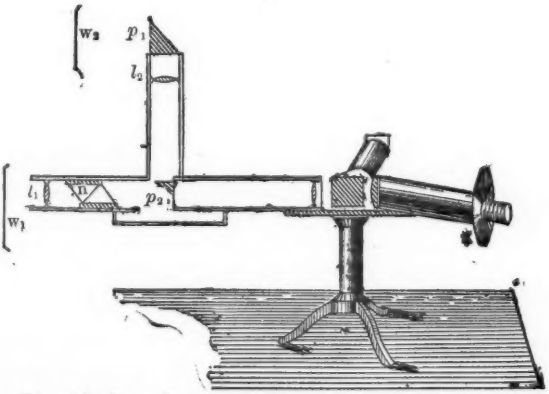
From this it is evident that differences in the quality of rays no longer visible to the eye, can be detected with the leucoscope.

The two platinum wires having been given the desired temperature by a proper adjustment of the Wheatstone's bridges, any change in the character of the light could be at once noticed by means of the galvanometer and leucoscope; and it was easy to determine whether, during the twelve to fifteen minutes course of a single experiment, any important change was caused by the loss of energy in the battery. Experience showed that the loss of intensity during a single experiment was so small that it could be left out of account.

II.

The experiments to be described in this paper were simply spectro-photometric comparisons of the light emitted by the two

3.



wires. One of the wires was given successively various temperatures between 1200° and 1900° of the platinum thermometer,* and all visible wave lengths radiated by this wire were compared with the corresponding rays from the other.

* See page 451.

The spectro-photometer used agreed with the already existing instruments in permitting the direct comparison of similar rays. The two horizontally dispersed spectra were vertically one above the other, so that in both equal wave lengths lay in the same line. It differed, however, in various particulars from the spectro-photometers of Vierordt, Glan, and Hüfner. The slit is bisected by the finely ground edge of the small rectangular prism p_2 (fig. 3). The lens l_1 throws an image of the glowing platinum wire w_1 upon the lower half of the slit. The rays of the other wire, w_2, after total reflection in the prism p_1, passage through the convex lens l_2 and a second total reflection in the small prism p_2, form a similar image upon the upper half of the slit. This pencil of rays is not polarized, whereas the rays from w_1 are polarized by passing the Nicol's prism n. Both sets of rays after passing the collimator tube, the large dispersing prism, the telescope and the ocular Nicol, reach the eye in form of two spectra, lying side by side. When the two sources of light are of equal intensity, and the planes of polarization of the two Nicols are parallel, the rays from w_1 suffer less loss in transmission to the eye, and give in consequence the brightest spectrum. Its intensity for all positions of the Nicol is given by the formula

$$I = \cos^2 \alpha, \qquad (3)$$

where α is the angle between the planes of polarization of the Nicols. The measurements were made by turning the ocular Nicol until the rays in the two spectra were equally bright. My experience in the use of the instrument was but a repetition of that of former observers. The varying delicacy of the eye at different times and for different colors, especially in the study of the extreme red and violet rays, influenced greatly the accuracy of the measurements.

An ordinary micrometric scale, such as are generally attached to spectroscopes, was used to mark the various spectral regions to be studied, and the position of the principal Fraunhofer's lines upon this scale having been carefully noted, it was made fast, and not moved again during the whole course of the investigations. These positions, according to the mean values of sixteen readings for each line, were as follows:

TABLE II.

Lines.	Scale-divisions.	Lines.	Scale-divisions.
A	7·35	b	12·84
B	8·05	F	14·63
C	8·74	G	19·03
D	9·95	H	23·28
E	12·37	----	----

III.

The accurate determination of the temperature of a glowing platinum wire, presents serious difficulties. Repeated attempts

to use Matthiesen's formula for the change of electric resistance with the temperature, only showed the impracticability of this method.

Only the middle portion of a glowing wire can be said to be of equal temperature throughout. If we measure the resistance of the wire when hot and cold (in itself no easy task), the change corresponds to a difference of temperature which gives, so to speak, the *mean* temperature of the whole wire; a quantity which must then be used, together with h and k (inner and outer conductivity of the metal), and with the dimensions of the wire, in the calculation of the distribution of temperature throughout its various parts. Aside from the difficulty of finding an applicable expression for this distribution, our imperfect knowledge of the quantities h and k for platinum, as functions of the temperature, would render the calculation of doubtful value.

The method finally adopted was to measure directly the expansion of the wire. By observing it from end to end with the leucoscope, while glowing, it was found that for a portion in the middle, about 60^{mm} long, the light radiated was, for the whole distance, of like character. This then was the greatest admissible length of the piece to be measured. In reality the section chosen was much shorter (45^{mm}), so that certainly within its limits, only imperceptible differences of temperature occurred.

A degree of the platinum thermometer may be defined as that change of temperature which causes in a platinum wire a linear variation of $1 : 1{\cdot}00000866$. Then for a wire 45^{mm} long, one degree corresponds to an expansion of about $0{\cdot}0004^{mm}$, and it was desirable in determining the temperature to be able to measure its length to within a few ten-thousandths of a millimeter. For this purpose I used a finely constructed Helmholtz's Opthalmometer; the following description of which is taken from Helmholtz's "Handbuch der physiologischen Optik," (p. 8). "The opthalmometer is essentially a telescope arranged for short distances, before the objective lens of which two glass plates stand side by side, so that one-half of the lens looks through the one, the other half through the other plate. When both plates are in a plane perpendicular to the axis of the telescope, there appears a single image of the object in view. Let them be turned a little, however, toward opposite sides, and the single image divides into two halves of a double image; the distance between which increases with the angle between the plates. This distance can also be calculated from the angle which the plates make with the axis of the telescope."

If a ray pass obliquely through a glass plate its displacement S will be, (fig. 4),

$$S = \frac{\sigma \sin (i - r)}{\cos r} \tag{4}$$

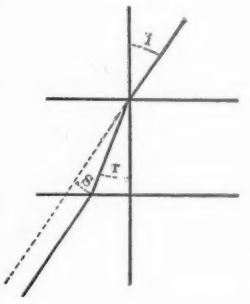
where σ denotes the thickness of the plates,
i denotes the angle of incidence,
r denotes the angle of refraction.
Eliminating r the equation becomes,

$$S\sqrt{1 - \frac{\sin^2 i}{n^2}} = \sigma \sin i \left(\sqrt{1 - \frac{\sin^2 i}{n^2}} - \frac{\cos i}{n}\right) \tag{5}$$

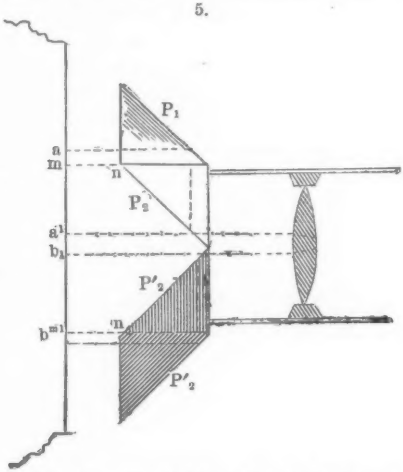
where n is the index of refraction.

The use of the opthalmometer offers great practical advantages over other micrometric methods, in that the angles corresponding to any given distances are independent of the distance of the object measured, and in that any slight unsteadiness of the object does not affect the accuracy of the determination.

4.



5.



The two end-points a and b (fig. 5) of the bit of wire to be measured, were, as already stated, about 45^{mm} apart; and some especial contrivance was therefore necessary to bring both of them at once into the field of the opthalmometer. A system of rectangular prisms $P_1 P_2 P'_1 P'_2$ arranged as shown in fig. 5 served this end. After two total reflections the images $a_1 b_1$ were nearly coincident. Angle readings with the opthalmometer are only possible to tenths of a degree, and I found that 6′ corresponded to a distance of 0·003^{mm}. To obtain greater delicacy I made use of a biconvex lens of as great magnifying power as the case permitted. There was a limit to the possible enlargement, since with too large an image the expansion

of the wire when heated sufficed to carry its ends out of the field of vision. In order that any unsteadiness of the wire might remain without influence on the measurements, the lens was attached, not to the opthalmometer, but together with the set of prisms upon the iron holder of the wire, so that possible jarring would effect rather the position than the size of the image. The second advantage of the instrument, that the reduction of angle readings to linear distances is the same whatever be the distance of the object from the eye, unfortunately disappears when the lens is used. The apparent distance between the images $a_1 b_1$ changes with the distance of the opthalmometer from the lens so that it was necessary to adjust the instrument once for all, and to keep it unchanged during the entire series of experiments. When a lens is used, the formula (5) instead of giving the real distance $a_1 b_1$, expresses merely the apparent distance between the images of a and b in the field of sight. The simplest modification consists in substituting another constant, which we shall denote by c for σ. The value of this constant was determined by exchanging the wire for a millimeter scale and noting the angles corresponding to displacements of the double images of $\frac{1}{4}$, $\frac{1}{2}$, etc., divisions of this scale. The scale was of boxwood and the half millimeters were marked by fine lines. The following table gives the angles corresponding to linear displacements of $\frac{1}{8}$, $\frac{1}{4}$, etc. millimeters. Each result is the mean of six readings.

TABLE III.

S	i
0·125mm	17° 3′ 0″
0·250	32 24 0
0·375	44 54 0
0·500	55 22 12
0·625	64 46 12
0·750	72 28 12

If in formula (5) c is substituted for σ and values from the above table for S and i, we obtain, n being known, from the equation,

$$S\sqrt{1-\frac{\sin^2 i}{n^2}} = c \sin i \left(\sqrt{1-\frac{\sin^2 i}{n^2}} - \frac{\cos i}{n}\right) \qquad (6)$$

the numerical solution,

$$c = 1{\cdot}03097^{\text{mm}}.$$

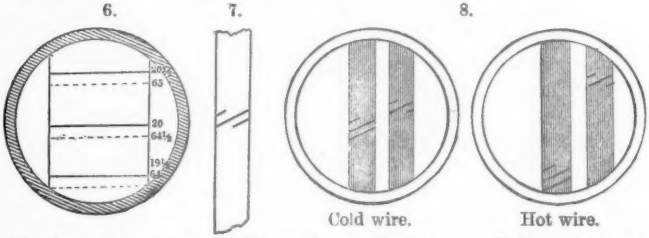
All the data necessary to the measurement of the distance $a_1 b_1$ were thus at hand. The distance $a b_1$ (fig. 5) is, however, $a_1 b_1 + m m_1$. Now the points m and m_1 are coincident in the field of the opthalmometer, appearing to lie at m_2; and their real distance can be measured by simply observing the double images of the above-mentioned scale as they appeared in the

field of sight. Images of two parts of the scale were brought by total reflections in the set of prisms into the field (see fig. 6), the portion lying between divisions 19½ and 20½, and overlapping this the portion from division 64 to 65. Now turning the plates of the opthalmometer until the lines 20 and 64·5 coincided, which occurred when the angle was, according to three successive readings, 29°·12′, 29°·18′, 29°·12′, sufficed to show how much the distance $m\,m_1$ exceeded $44{\cdot}5^{mm}$.

From formula (6) we find,

$$\overline{m\,m_1} = 44{\cdot}55748^{mm},$$

to which quantity it was only necessary to add for any state of the wire the directly obtainable value $a_1\,b_1$, in order to know $a\,b$, the length of the piece of wire in question.



Having chosen a and b as the end points of the wire to be measured, it was necessary in some way to mark them, so that when the wire was magnified the boundary lines should appear sharp, and at the same time be uninfluenced by the highest temperatures to which the metal was to be submitted. An indentation, be it ever so fine, will not only influence the temperature of the wire, but will even cause it to melt and break before the other portions have acquired the proper degree of heat. A ridge has the opposite effect, causing, in consequence of the increased conductive power, a dark ring upon the glowing metal. I employed, among other devices, minute glass beads, fused upon the wire in the desired places. This plan served very well at low temperatures, as it gave sufficiently sharp boundaries of demarkation; but as the heat increased, the melting of the glass next the metal destroyed the fineness of the boundary. It even happened at times that the entire bead would slip along to a new position on the wire. The following method, on the contrary, answered admirably. At the proper points simple loops of exceedingly thin platinum wire* ($0{\cdot}03^{mm}$ in diameter) were thrown around the larger wire. The latter having been brought to a white heat by means of the current, the loops were drawn tight at their appointed places. The

* This wire is prepared for use in the construction of electrometers.

small wire, fine as a fiber of raw silk, and scarcely visible to the naked eye, melted on touching the hot metal and became fixed upon its surface. The whole, seen through the microscope, appeared as in figs. 7 and 8. Since all the observations were made in a dark room, where, in the case of the cold wire, the marks would have been invisible, two small gas-flames were so placed that their rays, reflected from the loops of wire, appeared in the dark field of vision like two fine points of light. Such was the apparatus by means of which the temperatures given in the table of results were measured. It afforded all desired accuracy. The opthalmometer is free from many errors which by cathetometric and micrometric measurements are unavoidable.

The temperatures used varied from 1200° to 1900° of the platinum thermometer. Shortly after passing the latter point the platinum suffered a change of condition. It did not melt; but the wire lost its stiffness, hung down limp, scarcely holding together, and quivered when jarred like jelly. Under these circumstances measurements became unreliable. The very small weight* which hung at the lower end sufficed, as soon as the current became a trifle stronger, to stretch the wire in its weakest place. The conducting power being thus diminished, the temperature would rise very rapidly until after glowing brilliantly for a moment, the platinum would melt and the wire break.

IV.

Before the beginning of the experiments the two wires were adjusted in their iron holders before the slit of the spectrophotometer, which having been brought into its proper place and sealed fast, was not moved during the whole course of the investigation. The opthalmometer also, having been placed in the position most advantageous for the measurement of the expansion of the platinum wire, remained undisturbed throughout all the experiments. The leucoscope was set up two meters distant from the two wires.

The galvanic circuits of which the wires formed a part having been closed, and the few minutes necessary for the attainment of a constant temperature having elapsed, the deflection of the galvanometer and the condition of the constant wire as indicated by the leucoscope were noted. The temperature of the other wire was determined by the method described in

* If both ends of a cold platinum wire be fastened, and the wire be made to glow, the expansion resulting from this change of temperature suffices to move its center considerably from its original position. To avoid disturbance from this cause I fastened only one end of my wires, and inserted the lower ends into short copper rods, which dipped into small vessels of mercury. To prevent heating, the mercury vessels were placed in cold water.

the last paragraph, and then the spectro-photometric comparison of the rays emitted by the two wires carried out as rapidly and accurately as possible. Beginning with the wave lengths denoted by the scale-division 8 (see Table II), this being the point nearest the red end of the spectrum at which satisfactory results could be obtained, the intensities of the two spectra were compared in the spectral regions corresponding to divisions 9, 10, etc., to 19 in the neighborhood of line G_1 successively. Beyond 19 no accurate readings were possible.* The same measurements were then made in reverse order, from violet to red, and finally a second time from red to violet, and the mean values of these readings used.

After the completion of these readings the temperature of the wire was again taken, first in its glowing condition, and then, the circuit having been broken and time allowed for cooling, while cold. The deflections of the galvanometer and the temperature of the room were next noted, and last of all the constant wire again observed through the leucoscope. Whenever a difference in the measurements before and after an experiment pointed to a change of temperature in either wire, the experiment was set aside as imperfect.

The readings given in the following table will suffice to show the general character of the measurements.

TABLE IV.†

Scale-divisions.	Readings.	Mean.	$90°-a$.	Intensity.
8	37°·0 36 ·8 37 ·2	37°·00	20° 36′ 0″	·1238
9	36 ·0 36 ·3 36 ·0	36 ·10	19 42 0	·1136
10	32 ·5 33 ·5 32 ·9	32· 97	16 34 12	·08133
11	30 ·0 30 ·0 31 ·0	30 ·33	13 56 0	·05798
12	29 ·0 28 ·9 29 ·0	28 ·97	12 34 12	·04736
13	27 ·5 27 ·4 27 ·0	27 ·30	10 54 0	0·3576

* For the lower temperatures used, the spectrum was not visible even to line G. and measurements could only be carried out up to the scale-division nearest the limit of the visible rays.

† The figures in the column marked "Readings" denote the position of the pointer attached to the ocular Nicol. Subtracting from the mean of these readings for each part of the spectrum the position of the pointer when the Nicols are crossed, the quantity $90°-a$ is obtained. $90°-a$ being the angle between the planes of polarization of the two Nicols.

Scale-divisions.	Readings.	Mean.	90°−*a*.	Intensity.
14	25 ·9 26 ·7 26 ·4	26 ·33	9 56 0	·02976
15	24 ·0 23 ·3 24 ·3	23 ·87	7 28 12	·01696
16	24 ·0 23 ·5 24 ·0	23 ·83	7 25 48	·01600
17	----	----	----	----
18	----	----	----	----
19	----	----	----	----

From the 17th division onward the intensities were too small to allow of further measurements.

The other readings in the above experiment were as follows:

Before.

Leucoscope-readings	40°·6	40°·3
Opthalmometer-readings (for the hot wire)	56°·5	

After.

Leucoscope-readings	40°·5	40°·4
Opthalmometer-readings (for the hot wire)	56 ·5	56 ·5
Opthalmometer-readings (for the cold wire) 29°·4	29°·5	29°·5
Movement of the galvanometer during the experiment*		4cm
Temperature of the room		20°·1 C.

Applying the above readings in formula (6) we find as temperature of the hot wire 1539°·5 (of the platinum thermometer). I succeeded in obtaining thirteen such series of measurements at temperatures varying from 1932° to 1201°,† and covering wave lengths from scale-division 8 and the end of the visible spectrum in the direction of the violet. These results are given in the column marked "Observed," Table V. They can be approximately represented by curves the abscissæ of which are temperatures and whose ordinates are the corresponding quantities in the column marked "Calculated." The differences between the observed and calculated values are given in a separate column.

TABLE V.

Region 8 on Kirchhoff's Scale 609·1.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1201·1	0·061	0·004	+·006	1628·8	0·290	0·288	+·002
1256·9	0·006	0·005	+·001	1653·0	0·383	0·350	+·033
1358·3	0·041	0·026	+·015	1759·6	0·623	0·623	·000
1426·4	0·030	0·037	+·007	1901·7	1·421	1·417	+·004
1539·5	0·123	0·145	−·008	1932·7	1·760	1·959	+·001
1618·5	0·288	0·257	+·037				

* A movement of the spot of light over 1·25 meters corresponded to a change of temperature in the wire sufficient to be detected by the leucoscope. 4cm denoted a negligible decrease in temperature.

† Draper (Philosophical Magazine, xxx, 345) gives 525° C. as the point of temperature at which visible rays begin to appear. Granting the accuracy of this measurement, we find a long interval of at least 600° within which the intensity of even the red rays is exceedingly small compared to their intensity at 1900°. So far as the present method goes, they are immeasurably small.

Region 9 on Kirchhoff's Scale 813.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1201·1	0·004	0·003	+·001	1653·0	0·295	0·296	−·001
1256·9	0·004	0·004	·000	1689·7	0·341	0·389	−·048
1358·3	0·003	0·020	−·0165	1759·6	0·580	0·582	−·002
1426·4	0·0185	0·033	−·015	1901·7	1·411	1·409	+·002
1539·5	0·113	0·105	+·008	1932·7	1·740	1·739	+·001
1618·5	0·241	0·230	+·011				

Region 10 on Kirchhoff's Scale 1007.

1201·1	0·004	0·0028	+·0012	1628·8	0·207	0·216	−·009
1256·9	0·003	0·0035	−·0005	1653·6	0·249	0·257	−·008
1358·3	0·023	0·018	+·005	1759·6	0·572	0·565	+·007
1426·4	0·0162	0·025	−·0088	1901·7	1·395	1·370	+·025
1539·5	0·081	0·086	−·005	1932·7	1·698	1·695	+·003
1618·5	0·199	0·198	+·001				

Region 11 on Kirchhoff's Scale 1221.

1201·1	0·003	0·0025	+·0005	1628·8	0·204	0·197	+·007
1256·9	0·003	0·003	·000	1653·6	0·241	0·240	+·001
1358·3	0·0181	0·0125	+·0056	1689·7	0·307	0·314	−·007
1426·4	0·0151	0·0189	−·0038	1759·6	0·545	0·536	+·009
1504·8	0·048	0·047	+·001	1901·7	1·339	1·330	−·011
1539·5	0·058	0·076	−·018	1932·7	1·668	1·666	+·002
1618·5	0·170	0·170	·000				

Region 12 on Kirchhoff's Scale 1422.

1201·1	0·003	0·002	+·001	1618·5	0·130	0·135	−·005
1256·9	0·002	0·0025	−·0005	1653·6	0·220	0·200	+·020
1358·3	0·014	0·010	+·004	1689·7	0·267	0·271	−·004
1426·4	0·013	0·012	+·001	1759·6	0·523	0·486	+·037
1504·8	0·0139	0·0136	+·0003	1901·7	1·375	1·313	+·002
1539·5	0·047	0·063	−·016	1932·7	1·666	1·665	+·001

Region 13 on Kirchhoff's Scale 1629.

1201·1	0·002	0·0015	+·0005	1628·8	0·154	0·140	+0·14
1358·3	0·008	0·007	+·001	1653·6	0·161	0·173	−·012
1426·4	0·009	0·008	+·001	1689·7	0·236	0·240	−·004
1504·8	0·035	0·020	+·015	1901·7	1·225	1·225	·000
1539·5	0·036	0·038	−·002	1932·7	1·620	1·610	+·010
1618·5	0·109	0·125	−·016				

Region 14 on Kirchhoff's Scale 1833.

1201·1	0·001	0·001	·000	1653·6	0·154	0·151	+·003
1358·3	0·006	0·005	+·001	1689·7	0·208	0·210	−·002
1426·4	0·007	0·007	·000	1759·6	0·409	0·400	+·009
1504·8	0·029	0·022	+·007	1901·7	1·180	1·176	+·004
1618·5	0·091	0·101	−·010	1932·7	1·595	1·590	+·005
1628·8	0·133	0·118	+·015				

Region 15 on Kirchhoff's Scale 2037.

1358·3	0·005	0·005	·000	1628·5	0·114	0·099	+·015
1426·4	0·006	0·006	·000	1653·6	0·153	0·130	+·023
1504·8	0·019	0·013	+·006	1759·6	0·351	0·350	+·001
1539·5	0·018	0·015	+·003	1901·7	1·150	1·146	+·004
1618·8	0·073	0·080	−·007	1932·7	1·550	1·550	·000

Region 16 on Kirchhoff's Scale 2241.

1358·3	0·004	0·004	·000	1628·8	0·074	0·069	+·005
1426·4	0·006	0·005	+·001	1689·7	0·132	0·133	−·001
1504·8	0·013	0·010	+·003	1759·6	0·304	0·304	·000
1539·5	0·017	0·017	·000	1901·7	0·959	0·960	−·001
1618·5	0·067	0·059	+·008	1932·7	1·506	0·508	−·002

Region 17 on Kirchhoff's Scale 2445.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1504·8	0·010	0·009	+·001	1759·6	0·290	0·280	+·010
1539·5	0·017	0·015	+·002	1901·7	0·891	0·891	·000
1618·5	0·054	0·056	−·002	1932·	1·320	1·321	−·001
1689·7	0·108	0·108	·000				

Region 18 on Kirchhoff's Scale 2648.

1653·6	0·067	0·050	+·017	1901·7	0·795	0·799	−·004
1689·7	0·112	0·080	+·032	1932·7	1·249	1·249	·000
1759·6	0·274	0·240	+·034				

Region 19 on Kirchhoff's Scale 2853.

1689·7	0·060	0·059	+·001	1901·7	0·750	0·750	·000
1759·6	0·207	0·202	+·005	1932·7	1·203	1·200	+·003

The size of the above differences bears witness to the difficulties which, aside from those which are unavoidable, even in the study of the most favorable colors at intensities best adapted to the eye, stand in the way of accurate results. At the lowest temperatures, where the weaker spectrum had only a few thousandths the intensity of the other, exactness was quite out of the question. How vastly the eye varies in delicacy according to the color of the light, is shown by the following measurements of the intensity of various rays necessary to produce in the eye the perception of color. One finds upon turning the ocular Nicol from the position of maximum brightness to that where the ray becomes completely extinguished, that in the case of the red rays on the one hand and of the blue and violet on the other, this point is much sooner reached than with the yellow and green rays. The position of the ocular Nicol, at which each ray of the spectrum disappears, is given in the column marked "$90°-\alpha$" of table VI. The corresponding intensities are shown under "$\sin^2(90-\alpha)$" and in the column marked "optical action" is given the power of the respective rays upon the eye.

TABLE VI.

Region.	$(90-\alpha)°$	$\sin^2(90-\alpha)$	Optical action.	Region.	$(90-\alpha)°$	$\sin^2(90-\alpha)$	Optical action.
7	7·32	0·01719	0·1782	14	3·54	0·04620	0·0662
8	1·45	0·00932	0·3284	15	5·0	0·07592	0·0432
9	1·6	0·00363	0·6601	16	7·24	0·16560	0·0184
10	1·0	0·00306	1·0000	17	8·30	0·21600	0·0142
11	2·6	0·01340	0·2281	18	9·36	0·27801	0·01117
12	2·18	0·01611	0·1900	19	12·36	0·44662	0·0068
13	2·42	0·02221	0·1380	20	15·36	0·72320	0·0023

These results are introduced here, to show with what immense subjective differences we have to do in studying the visible spectrum. However valuable such researches might prove to show remarkable variations of the eye with regard to its perceptive power for various colors, these very changes render the experiments useless in the investigation of the real energy of the rays themselves.

In table V the intensities of the various wave lengths for all the temperatures in question are expressed in terms of the intensities of corresponding wave lengths of a similar spectrum of constant but unknown temperature. For each individual ray, the measurements give the change of intensity resulting from a given change of temperature; but since the relative intensity of the various wave lengths of the spectrum of constant temperature are unknown, it is impossible to compare rays of different wave length with each other.

Before describing the way in which all the above results were reduced to a common basis for the purpose of comparison, a clear definition of the expression "intensity of ray" as used in this paper is desirable.

It is first of all essential to distinguish between the intensity of the ray itself and the intensity of its various effects upon bodies upon which it may fall. It is usual to define as the intensity of the ray itself, its energy of vibration or the square of the amplitude of vibration. Kirchhoff however (§ 2 of his above mentioned treatise), defines as the energy of the ray passing the openings of the screens S_1 and S_2 (fig. 1) the increase in a unit of time of the vis viva of the ether behind the second screen. This definition is the more appropriate to the case at hand. Suppose that for the opening S_2 a black body be substituted. In accordance with the principle of the Conservation of Energy, as expressed in the usual equation,

$$T_1 - T_0 = \int_{t_0}^{t_1} \Sigma (X\,dx + Y\,dy + Z\,dz) = U, \qquad (7)$$

where T_1 and T_0 are the energy (*lebendige Kraft*) before and after the interval of time, and U, denotes the work performed; the increase in energy in the body equals in the unit of time, the work performed by the action of the ray. We may then consider this work as the measure of the intensity of the ray itself. Suppose further, the body be molecularly so constituted that no chemical action takes place, that in short the entire energy of the ray be converted into heat. The amount of heat produced may in this case be taken as the measure of the intensity of the ray itself. This heat, as denoted by the change of temperature of the body, is the result of what is termed the thermal action of the ray, so that the intensity of the ray itself, which I shall call the *mechanical intensity of the ray*, because it is directly expressible in units of work,—is proportional to the intensity of the thermal action, or the *thermal intensity of the ray.*

The *chemical** and *optical intensities of the ray* stand in as yet

* Clerk Maxwell, Theory of Heat, p. 240, offers a very ingenious suggestion as to the real nature of the chemical action of light. "It is probable that when the radiation produces the photographic effect, it is not by its energy doing work on the chemical compound, but rather by a well-timed vibration of the molecules dis-

unknown relation to the mechanical intensity. They are only known in connection with a small class of substances, the optical action seeming to affect a single body only (the retina of the eye). They occur only in certain limited sets of rays, and depend largely for their effect upon the nature and condition of the body acted on. They are therefore useless as measures of the mechanical intensity.

The intensities given in Table V are, however, simply expressions for the square of the amplitudes, and therefore directly proportional to the thermal actions of the respective rays. The thermal intensities of these rays being, at the temperatures available, too small for direct measurement, the easiest way of determining their values is by making a spectrophotometric comparison with the corresponding rays of the sun's spectrum, the thermal intensities of which have been most carefully measured. The best determinations of the sun's spectrum are by Lamansky,* whose results for the visible rays, with the dispersion of a crown-glass prism, are, when adapted to the scale used in my researches as follows:

TABLE VII.

Region.	On Kirchhoff's Scale.	Thermal Intensity.	Region.	On Kirchhoff's Scale.	Thermal Intensity.
8	609·1	0·826	14	1832	0·302
9	813	0·703	15	2037	0·245
10	1017	0·605	16	2241	0·200
11	1221	0·530	17	2445	0·163
12	1422	0·453	18	2628	0·130
13	1629	0·375	19	2853	0·099

The unit in this table is the intensity at the point of maximum heat for the whole spectrum, which lies beyond the last of the visible red rays.

The comparison of the sun's spectrum with that of the platinum wire was made in this way. Diffuse daylight—as reflected from white clouds was used instead of the direct rays of the sun, repeated trials with the leucoscope having shown these to be of identical composition. The pencil of this light was substituted for the rays from the platinum wire of constant temperature. The other wire was given a temperature of 1607° (platinum thermometer), and the measurements were made in a manner precisely similar to that already described. Table VIII contains the readings and results of this comparison.

lodging them from the almost indifferent equilibrium into which they had been thrown by previous chemical manipulations, and enabling them to rush together according to their more permanent affinities so as to form stabler compounds." If this be true, we have evidently to do with work arising from energy stored up by previous chemical action, and therefore not all ascribable to the energy of the ray.

* Lamansky, Poggendorff's Annalen, cxli.

TABLE VIII.

Comparison of the sun's spectrum with that of glowing platinum.

Region.	Reading.	Mean.	$9° - a$.	Intensity.
8	106°·3 106·5 106·4	106°·4	90° 0′	1·000
9	99·0 98·4 99·6	99·0	72 36	0·91057
10	67·0 68·0 67 5	67·5	51 6	0·60570
11	45·0 44·0	44·5	28 6	0·22185
12	37·0 37·0	37·0	20 36	0·12380
13	31·9 32·9	32·4	16 0	0·07600
14	30·0 30·0	30·0	13 36	0·05529
15	27·5 27·0	27·25	10 43	0·03457
16	26·2 25·8	26·0	9 36	0·02781
17	23·9 24·0	23·95	6 33	0·01300
18	22·1 21·9	22·0	5 36	0·00951
19	20·0 20·0	20·0	3 36	0·00394

With the help of these measurements and of Lamansky's results just given, the intensities of the platinum spectrum for the various temperatures can be reduced to a common unit, and the results in this new form made to express not only the influence of temperature upon each ray considered separately, but, what is equally important, the relations between the intensities of all visible wave lengths by constant temperature.

Using the values, in the column marked "calculated" (Table V), I have constructed a table which gives for intervals of 25°, from 1200° to 1900° (platinum thermometer), the intensities corresponding to the wave lengths between scale-divisions 8 to 19 in terms of the intensity of the spectral-region corresponding to division 10 when the platinum was at 1900°.

This value was chosen as the unit because the position of division 10 could be simply and accurately defined. This region corresponds so nearly with line D, that it may be defined as *the region bordering on line D, on the side nearest the violet.* This table (IX) which may be, not inaptly, termed *Isothermic*, is arranged according to temperatures.

TABLE IX (Isothermic).

Regions.		Intensity.							
		1900°	1875°	1850°	1825°	1800°	1775°	1750°	1725°
8	or 609·1mm	1·7071	1·4285	1·234	1·078	0·9470	0·830	0·732	0·637
9	813	1·2102	1·026	0·874	0·748	0·6322	0·552	0·480	0·416
10	1017	1·0000	0·852	0·721	0·606	0·5147	0·436	0·379	0·322
11	1221	0·3665	0·315	0·269	0·257	0·1844	0·150	0·123	0·096
12	1422	0·1975	0·163	0·149	0·115	0·0946	0·076	0·064	0·055
13	1629	0·1086	0·089	0·076	0·063	0·0512	0·042	0·034	0·027
14	1833	0·0758	0·058	0·052	0·046	0·0351	0·030	0·025	0·019
15	2037	0·0445	0·036	0·033	0·027	0·0216	0·018	0·016	0·013
16	2241	0·0391	0·027	0·024	0·020	0·0176	0·013	0·010	0·008
17	2445	0·0282	0·019	0·015	0,013	0·0123	0·006	0·005	0·004
18	2648	0·0256	0·014	0·011	0·009	0·0108	0·003	0·0025	0·002
19	2853	0·0160	0·008	0·005	0·004	0·0071	0·0015	0·0012	0·0007
		1700°	1675°	1650°	1625°	1600°	1575°	1550°	1525°
8	or 609·1mm	0·5512	0·472	0·395	0·326	0·2719	0·214	0·169	0·131
9	813	0·3667	0·304	0·256	0·210	0·1694	0·128	0·100	0·076
10	1017	0·2774	0·228	0·187	0·155	0·1221	0·092	0·068	0·052
11	1221	0·0668	0·052	0·042	0·033	0·0277	0·023	0·020	0·016
12	1422	0·0447	0·037	0·027	0·021	0·0183	0·0170	0·015	0·007
13	1629	0·0238	0·016	0·014	0·012	0·0093	0·007	0·006	0·004
14	1833	0·0131	0·012	0·009	0·006	0·0054	0·003	0·0025	0·0015
15	2037	0·0075	0·007	0·005	0·004	0·0027	0·0025	0·0020	0·0010
16	2241	0·0061	0·005	0·002	0·002	0·0018	0·0016	0·0013	0·0007
17	2445	0·0037	0·0005	0·0009	0·0009	0·0007	0·0007	0·0005	0·0004
18	2648	0·0029	0·0006	0·0005	0·0004	0·00025	0·00022	0·0020	0·0001
19	2853	0·0017	0·0004	----	----	----	----	----	----
		1500°	1475°	1450°	1425°	1400°	1375°	1350°	1325°
8	or 609·1mm	0·0922	0·067	0·056	0·047	0·0388	0·032	0·027	0·022
9	813	0·0576	0·046	0·037	0·028	0·0227	0·0170	0·0119	0·0113
10	1017	0·0382	0·029	0·026	0·020	0·0176	0·0121	0·011	0·008
11	1221	0·0120	0·0113	0·011	0·009	0·0043	0·004	0·004	0·003
12	1422	0·0046	0·003	0·0025	0·002	0·0018	0·0015	0·0012	0·0003
13	1629	0·0019	0·001	0·0008	0·0005	0·0015	0·0004	0 00035	0·00021
14	1833	0·0009	0·0007	0·0005	0·0002	0·00019	0·00017	0·00015	0·00010
15	2037	0·0005	0·0004	0·0003	0·00015	0·00007	0·00006	0·0005	----
16	2241	0·0002	0·00017	0·00014	0·00009	0·00004	----	----	----
17	2445	0·0006	0·0006	----	----	----	----	----	----
18	2648	0·0003	----	----	----	----	----	----	----
19	2853	----	----	----	----	----	----	----	----
		1300°	1275°	1250°	1225°	1200°	....	....	....
8	or 609·1mm	0·0182	0·017	0·015	0·012	0·0097	----	----	----
9	813	0·0096	0·008	0·006	0·005	0·0043	----	----	----
10	1017	0·0046	0·004	0·002	0·0018	0·0013	----	----	----
11	1221	0·0009	0·0007	0·0006	0·0005	0·00038	----	----	----
12	1422	0·0002	0·00015	0·0001	----	----	----	----	----
13	1829	0·0000	0·00007	----	----	----	----	----	----
14	1838	----	----	----	----	----	----	----	----

The two sets of curves constructed from this table serve to render the character of these results more evident. In Diagram A, are drawn *Isothermals*, curves of equal temperature, in which the abscissæ are wave lengths, the ordinates intensities. Diagram B, gives the *Isochromatics*, or curves of equal wave lengths, with temperatures as abscissæ and intensities as ordinates. The first set shows the

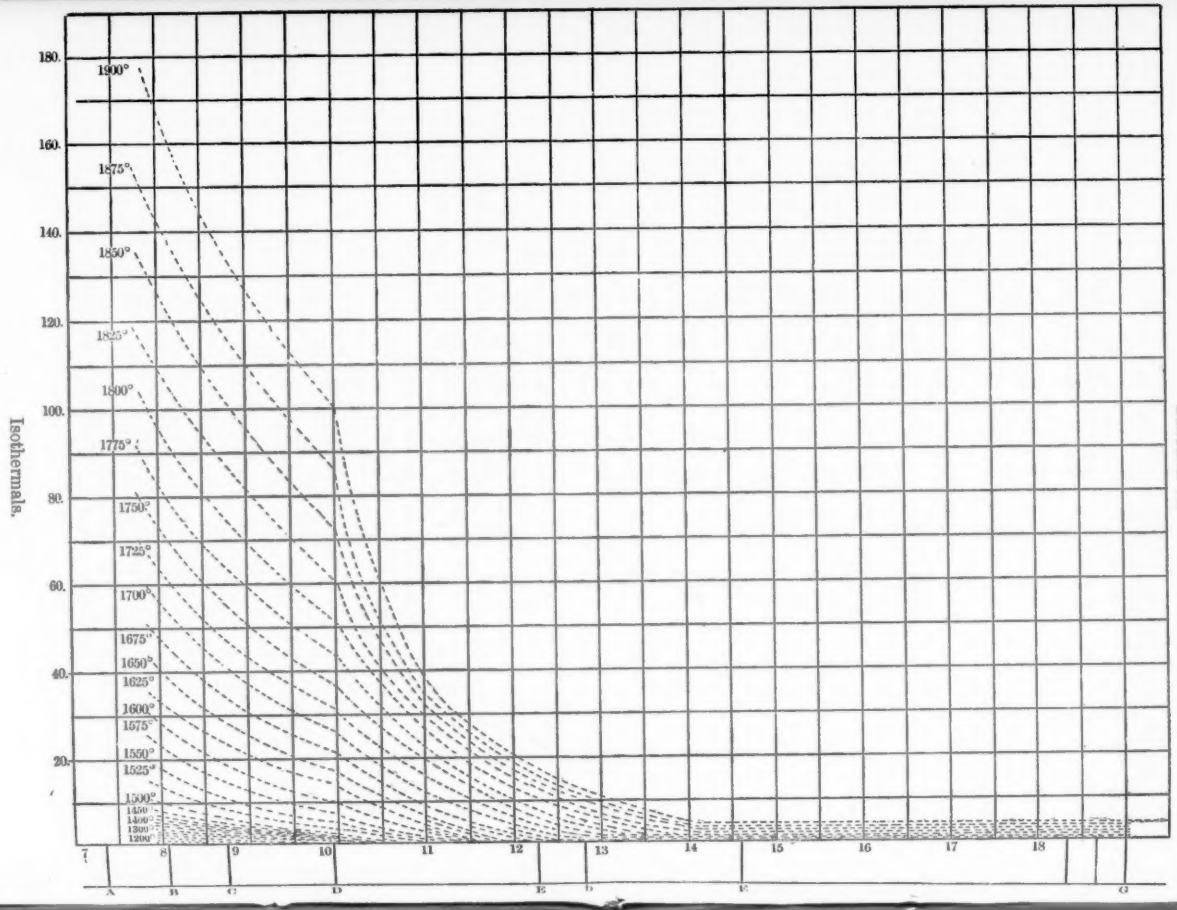

Isothermals.
1900°
1875°
1850°
1825°
1800°
1775°
1750°
1725°
1700°
1675°
1650°
1625°
1600°
1575°
1550°
1525°
1500°
180.
160.
140.
120.
100.
80.
60.
40.
20.
7
8
9
10
11
12
13
14
15
16
17
18
A
B
C
D
E
F
G

DIAGRAM A.

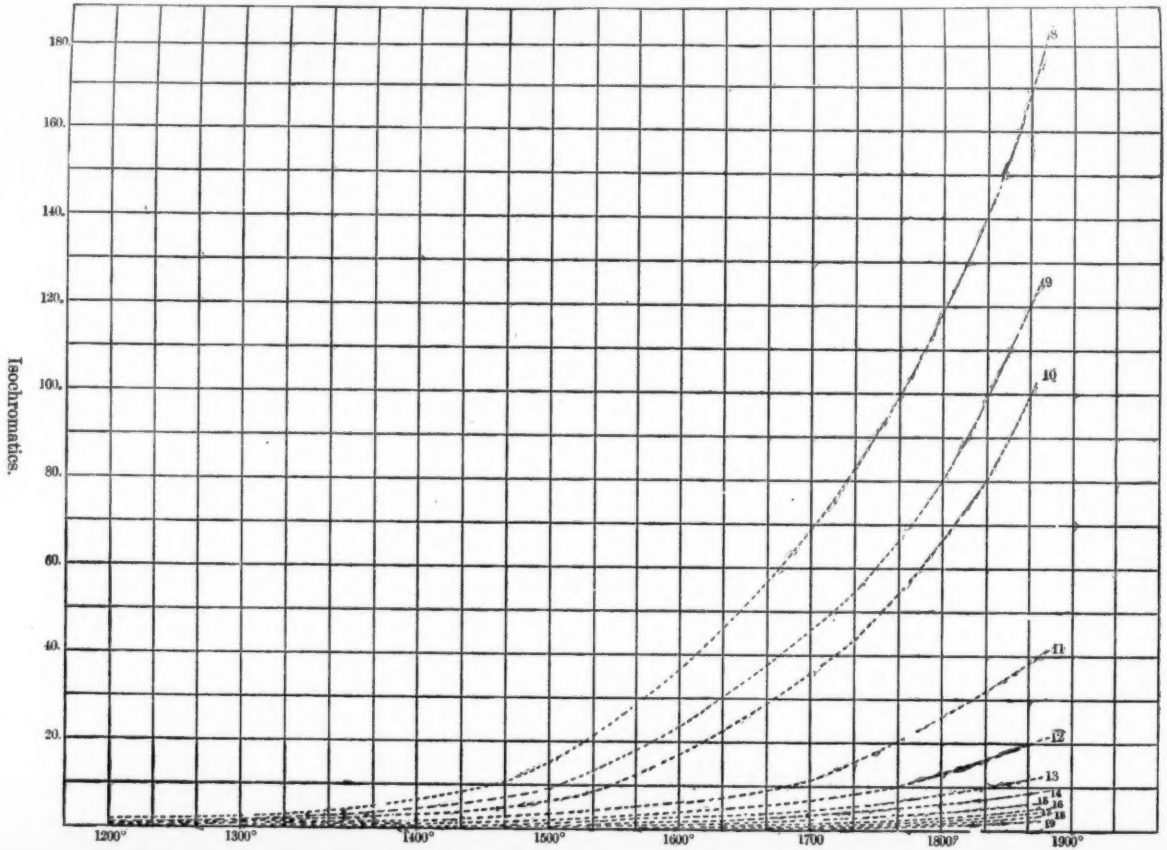

Isochromatics.
180.
160.
140.
120.
100.
80.
60.
40.
20.
8
9
10
11
12
13
14
15
16
17
18
19
1200°
1300°
1400°
1500°
1600°
1700
1800°
1900°

DIAGRAM II.

comparative intensities of the various parts of the visible spectrum by constant temperature, the latter denotes the influence of variations of temperature upon the intensity of each individual series of rays.

How exceedingly small the intensity of the more refrangible rays is, even at 1900°, compared with that of the spectral regions between line D and the red end of the spectrum, is equally evident in both sets of curves. A striking peculiarity of the isothermals is the too large value of the intensity of region (10). This unlooked-for feature can scarcely be due to a corresponding irregularity in the platinum spectrum, and at the same time it is in all probability no accidental error. Such an error, in order to produce such an effect in *all* the isothermic curves, must be looked for either in my comparison of the sun's spectrum with that of the platinum wire, or in Lamansky's measurements of the sun's heat. As to the former, we find by reference to the table, that the result in question is calculated from the mean of three readings of fair agreement. An error of several degrees in these determinations would be necessary to bring about any such irregularity as exists in the curves. Lamansky's results are also the mean of numerous measurements, and the occurrence of so large an error just at this point would at once be detected.

A curious fact recorded by Vierordt* while studying the spectra of gases, offers, I think, the true explanation of the irregularity. He observed, that even in absorptions-spectra, with clearly defined lines, no real discontinuity in the intensity of contiguous rays occurs, that, on the contrary, very sudden, but perfectly continuous, changes take place at the edge of each bright or dark line. The region (10) corresponds however, to the edge of the line D, (see pages 13 and 40), and would consequently in the sun's spectrum be weaker, owing to the proximity of the absorption line, than in a perfectly continuous spectrum. In the platinum spectrum, on the other hand, this region would possess its normal brightness, or in case, as generally happens, the surrounding atmosphere contained a trace of sodium, would form the edge of a bright line D, and be of more than normal intensity. This fact would tend, in the comparison of the spectra, to the production of just such an irregularity as appears in the curves on Diagrams A and B.

Kirchhoff, in his treatise (§ 15), draws the following *à priori* conclusions from his discussion:

"If a body, a platinum wire for example, is gradually heated, it emits until attaining a certain temperature, only rays the wave lengths of which are greater than those of the visible spectrum. At a certain temperature, rays of wave lengths cor-

* Vierordt, Poggendorff's Annalen, 151.

responding to the extreme red begin to appear. As the body becomes hotter and hotter, rays of shorter and shorter wave lengths show themselves, so that for each temperature a new set of rays first makes its appearance, while at the same time, the intensity of those already at hand continues to increase. Applying the principle we have already proved to this case, we see that the function I for any given wave length is equal to 0 for all points below a certain temperature corresponding to this wave length; and that for all temperatures above this point, the function I increases with the temperature."

Strictly speaking, however, the temperature at which each individual wave length becomes visible depends solely upon the sensitiveness of the observer's eye. We are furthermore forced to conclude from the experiment recorded in table VI, that the more refrangible rays really exist at temperatures far below those at which we begin to see them. The directions of the curves (Plates I and II) seem to denote, that all the rays studied begin to be emitted at some temperature not included in the interval embraced by the experiments. I suspect indeed that all of them originate at some very low degree (the absolute zero?) and are recognizable no sooner, simply because the various instruments at command, the thermopile, eye, photographic plate, etc., are not more delicate. That the various colors do not appear simultaneously, follows from the very different degrees of sensitiveness shown by the eye for different rays.

A fuller discussion of the results given in this paper, of their application in the study of the function I, and of an optical method, based upon them, for the measurement of high temperatures, will be given in another article. I will conclude with a single remark concerning the scale of temperatures used in this paper.

In view of the present ignorance of the law of expansion for platinum at high temperatures, it seemed better instead of trying to reduce my measurements to Celsius' degrees of the air thermometer, to constitute by means of a simple definition a scale for the platinum thermometer, which should be quite independent of other standards, and which could easily be expressed in terms of the existing scales so soon as the necessary investigations of the expansion of platinum had been made.

The already existing researches extend only over ordinary temperatures, and the empirical formulæ based upon them being only strictly applicable to the interval covered by actual experiment, a reduction obtained by use of them for an interval between the red heat and melting point would be at best of doubtful value. I give, nevertheless, such a reduction, founded

upon Matthiessen's* formula for the expansion of platinum between 0° C. and 200° C. This formula reads,

$$l = l_0 (1 + 0{\cdot}00000851\, t + 0{\cdot}0000000035\, t^2)$$

and the reductions are given in the following table:

TABLE X.

Platinum.	Celsius.	Platinum.	Celsius.
1900°	1294°	1500°	1081°
1800	1238	1400	1025
1700	1188	1300	968
1600	1129	1200	910

Of the accuracy of this comparison there are at present no means of deciding. Taking into consideration, however, the attempts already frequently made, to estimate the temperature of flames, glowing metal, etc., it seems likely that the above values, in degrees Celsius, are considerably too small.

Rosetti of Venice gives, for example, for the hottest portion of a Bunsen's burner flame, 1350°. According to Pouillet,† the melting points of various metals are as follows:

Wrought-iron	1600° C.	Cast-iron	1200 C. 1050° C.
Steel	1400 C. 1300° C.	Gold (pure)	1200 C., etc.

Peekskill, N. Y., May 28, 1879.

ART. LVII.—*Notice of recent Additions to the Marine Fauna of the Eastern Coast of North America, No.* 7; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLIV.

AMONG the numerous additions recently made to the marine fauna of our coast by the fishermen of Gloucester, Mass., are two new species of Cephalopods. They both belong to the eight-armed division. One is a true *Octopus*. The other and more interesting one is the second known representative of the remarkable family of *Cirroteuthidæ*, characterized by the presence of a pair of fins, one on each side of the body, supported by a transverse cartilage; by the presence of a great web, surrounding and uniting all the arms, nearly to their tips; and by the presence of two slender cirri between the suckers, along the greater part of the length of the arms.

Our species differs so widely from *Cirroteuthis Müllerí* Esch., the only representative of the family hitherto described, that it is necessary to constitute for it a new genus.

Stauroteuthis, gen. nov.

Allied to *Cirroteuthis*, but with the mantle united to the head all around, and to the dorsal side of the slender siphon, which it surrounds like a close collar, leaving only a very narrow opening around the base of the siphon, laterally and ventrally.

* Matthiesen, Phil. Mag., VI, vol. xxxii. † Pouillet, Comptes Rendus, i, ii.

Fins triangular, in advance of the middle of the body. Dorsal cartilage forming a median angle directed backward. Body flattened, soft, bordered by a membrane. Eyes covered by the integument. Web not reaching the tips of the arms, the edge concave in the intervals. Suckers in one row. Cirri absent between the basal and terminal suckers. Right arm of second pair is altered, in the male, at the tip.

Stauroteuthis syrtensis, sp. nov.

♂. Head broad, depressed, not very distinct from the body. Eyes large. Body elongated, flattened, soft or gelatinous, widest in the middle, narrowed but little forward, but decidedly tapered, back of the fins, to the flat, obtuse, or subtruncate tail. The sides of the head and of the body, forward of the fins, are bordered by a thin soft membrane, about half an inch wide. The fins are elongated, triangular, obtusely pointed, placed in advance of the middle of the body. Siphon elongated, slender, round, with a small terminal opening. Mantle edge so contracted and thickened around its base as to show scarcely any opening, and united to it dorsally. Arms long, slender, subequal, each united to the great web by a broad membrane developed on its outer side, widest (about 1·5 inch) in the middle of the arm, while the edge of the web unites directly to the sides of the arms and runs along the free portion toward the very slender tip, as a border. This arrangement gives a swollen or campanulate form to the extended web. Edges of the web incurved between the arms, widest between the two lateral pairs of arms. The arms bear each fifty-five or more suckers, in a single row. Those in the middle region are wide apart (·5 inch or more) with a pair of slender, thread-like cirri, about 1 inch long, midway between them. The cirri commence, in a rudimentary form, between the 5th and 6th suckers, on the dorsal arms, and between the 7th and 8th, on the ventral ones. They cease before the 23d sucker on the dorsal and lateral arms, and before the 22d on the ventral ones. Near the mouth, and beyond the last cirri on the free portion of the arms, the suckers are more closely arranged. They are small, with a deep cavity. Color, in alcohol, generally pale with irregular mottlings and streaks of dull brownish; inner surface of arms and web, toward the base, and membrane around the mouth, deep purplish brown. Length from end of body to base of arms, 6·30 inches; length to posterior base of fins, 2·50; to anterior base, 4; width across fins, 5; in advance of fins, 2·70 (not including lateral membrane); across eyes, 1·75; across end of tail, 1·20; diameter of eye, 1; width of fins, at base, 1·20; their length, 1·75; length of arms, 13 to 14 inches; portion beyond web, 2·5 to 3 inches. Edge of extended web, between upper arms, about 4 inches; between lateral arms, about 8 inches; entire circumference of web, about 48 inches.

Taken by Capt. Melvin Gilpatrick and crew, schooner "Polar Wave," N. lat. 43° 54′; W. long. 58° 44′, on Banquereau, about 30 miles E. of Sable I., in 250 fathoms. Presented to the U. S. Fish Commission, Sept., 1879.

***Octopus piscatorum*, sp. nov.**

Body of female is smooth, depressed, about as broad as long. Obtusely rounded posteriorly, not showing any lateral ridges, nor dorsal papillæ. No cirrus above the eyes. Arms long, rather slender, tapering to long, slender, acute tips, the upper ones a little (·1 of an inch) shorter than those of the second pair, which are the longest; the third pair are about one-half inch shorter than the second; the ventral pair about one-fourth inch shorter than the third. In our specimen all the arms on the right side are somewhat shorter than those on the left, and the web between the 1st and 2d arms is narrower, due perhaps to recovery from an injury. The suckers are moderately large, alternating in two regular rows, except close to the mouth, where a few stand nearly in a single line; about fourteen to sixteen are situated on the part of the arms included within the interbrachial web. The whole number of suckers on one arm is upwards of seventy. The web between the arms, except ventrally, is of about equal width, and scarcely more than one-fourth the length of the arms, measuring from the beak. Between the ventral arms the web is about half as wide as between the lateral.

Color of alcoholic specimen, deep purplish brown, due to very numerous crowded, minute, specks; eye-lids whitish. The front border of mantle, beneath, with base of siphon and adjacent parts, is white; end of siphon brown. Lower side of head and arms lighter than the dorsal side. Total length, from posterior end of body to tip of arms, of 1st pair, 6·20 inches; 2d pair, 6·30; 3d pair, 5·75; 4th pair, 5·25; to web between dorsal arms, 3·25; between ventral arms, 2·50; to edge of mantle, beneath, 1·20; to center of eye, 1·55. Breadth of body, 1·25; of head across eyes, 1·20; breadth of arms, at base, ·22; diameter of largest suckers, ·10; length of arms, beyond web, 1st pair, 3·00; 2d pair, 3·25; 3d pair, 2·80; 4th pair, 2·75.

Taken by Capt. John McInnis and crew of the schooner "M. H. Perkins," from the western part of Le Have Bank, off Nova Scotia, in 120 fathoms. Presented to the U. S. Fish Commission, Oct. 1879.

This species is easily distinguished from *O. Bairdii*, by its more elongated body, its much longer and more tapered arms, with shorter web; by the absence of the large, rough, pointed papilla, or cirrus, above the eyes, and by its general smoothness. The white color of the underside of the neck, siphon and mantle-border also appears to be characteristic.

ART. LVIII.—*Notes on the Geology of Galisteo Creek, New Mexico;* by JOHN J. STEVENSON, Professor of Geology in the University of the City of New York.

GALISTEO CREEK rises near the southern end of the Santa Fe mountains and flows southward for nearly fifteen miles to Galisteo; where, being increased by the Arroyo San Cristobal, coming from the east, it turns westward and flows in that direction to the Rio Grande. Its area is divided by a narrow dike, which forms a distinct ridge and separates the portion drained by the creek in its southward flow, from that drained by the Arroyo San Cristobal and the creek in its westward flow. These divisions may be distinguished as the upper and the lower area of the Galisteo. The region is not wholly unknown to geologists, for it has been visited by Dr. Newberry, Dr. Hayden and Professor Cope, whose views respecting the age of the coal beds and of the peculiar Galisteo sandstone are not in accord. The details of my observations there will be given in my report to Captain Wheeler; here, by consent of the Chief of the Engineer corps, U. S. A., a brief résumé of the results will be given, in so far as they bear upon the matters in dispute.

The shales of the Fort Pierre group (No. 4 of Mr. Meek's general section) are shown at barely sixteen miles below Galisteo dipping gently eastward in mesas on both sides of the creek. They have all the characteristic features of that group and yield its peculiar fossils at many localities. The Laramie group rests on them, and its western outcrop is reached on the south side of the creek at somewhat less than sixteen miles below Galisteo. There the rocks dip toward the east-northeast and at a low angle; this is the northern termination of an extensive area of Laramie, reaching southward for many miles and surrounding the Placer and Sandia mountains. The eastern outcrop of the Laramie beds passes rudely north and south through Galisteo, and there the dip is westward. The width of the area from east to west along the creek is not far from fifteen miles.

A detailed section of 440 feet, taken on the western outcrop, bears no resemblance in detail to sections from the same horizon in the Trinidad coal field, and correlation of the beds in the two fields is not possible. The coal beds in the Galisteo area are thin and variable, and little of economic interest exists aside from the anthracite beds, which contain coal altered by the influence of a gigantic dike passing between the Placer mountains and Galisteo creek. But there is much material of scientific interest, for the Laramie beds show an unexpected intimacy with the underlying Fort Pierre.

Passing the eastern outcrop of the Laramie, one comes at once to a wide park, lying mostly on the south side of the Arroyo San Cristobal and eroded amid the Colorado shales. The Fort Pierre sub-group occupies the western side of this park and, as usual, is much thicker than are the Niobrara and Fort Benton combined. Its shales show the ordinary features, for here are the lines of huge ferruginous concretions, of calcareous concretions, and the succession of dark, gray and yellow shales with abundance of selenite crystals. The concretions, except where showing a cone-in-cone structure, are full of fossils; enormous *Inocerami* with smaller species are common, *Ammonites*, *Baculites*, *Tachytriton*, *Aporrhais*, *Gyrodes*, *Fasciolaria* and *Ostrea* are abundant, all of them belonging to species occurring in the Fort Pierre group at other localities farther north.

Below the Fort Pierre are the bluish-gray argillaceous limestones of the Niobrara sub-group (Cretaceous No. 3) with the same physical features everywhere shown throughout the whole region south from Denver, and containing *Inoceramus problematicus* along with other species always regarded as characterizing this horizon. The exposures of this group are few but ample. An excellent exhibition can be seen at barely a mile southeast from Galisteo, where the limestone was quarried to be burned into lime. The dark brown shales of the Fort Benton (Cretaceous No. 2) are ill-exposed at the base of the Dakota mesa, which forms the eastern boundary of the park, south from the Arroyo.

The Dakota is well exposed, the three provisional groups, which will be proposed in my report, being shown along the Arroyo San Cristobal. The Upper Dakota forms the mesa or east wall of the park and consists of light gray and yellow sandstones; the Middle Dakota consists of blue, white and red sandy to clayey shales, with a bed of limestone, a conglomerate of limestone and iron ore and streaks of gypsum; while the Lower Dakota, made up of gray and yellow sandstones like those of the Upper Dakota, reaches eastward and becomes the upper part of a great mesa, the southwest wall of the Pecos valley.

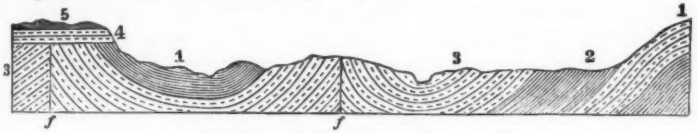
The succession in the lower Galisteo area is absolutely clear, showing the Dakota, Fort Benton, Niobrara, Fort Pierre and Laramie groups in their proper order. All of these dip westward until perhaps eight miles below Galisteo, where the dip is reversed so that the Laramie beds run out at sixteen miles below Galisteo and the Fort Pierre shales come again to the surface. Each of these groups is perfectly characterized and no difficulty is encountered in the attempt to identify them. The physical features and the fossils are not materially different from those found elsewhere in the same groups within the

whole region south from Denver, except that *Halymenites major*, so common at the base of the Laramie group in the Trinidad coal field, is absent here. But impressions of dicotyledonous plants occur in the Galisteo region, which are closely allied to those found in the Trinidad coal field. The coal beds on the northeast slope of the Placer mountains are as clearly Laramie as are those of the Trinidad or the Cañon City coal field.

But the geology of the upper Galisteo area is far from being so simple as that observed along the south side of the creek within the lower area.

No reference has been made to the north side of the creek within the lower area; that can be considered more conveniently in connection with the upper area. A broad uneven park, designated on the Engineer map as the Arroyo de Los Angeles, opens into the lower area at perhaps five miles below Galisteo, and the dike, previously referred to, forms its southeast boundary for several miles.

If a section be carried across the area of the upper Galisteo near its southern edge, the conditions will be found such as are represented in the following diagram.



CROSS SECTION ON THE UPPER GALISTEO.

1. Dakota. 2. Colorado. 3. Laramie. 4. Galisteo. 5. Alluvium.

The Upper Dakota sandstone is in the bluff on the east side, where the dip is very rapid; behind it are the shales and limestones of the Middle Dakota, and the sandstones of the Lower Dakota are shown still further east. Going westward toward Galisteo creek, one crosses the Dakota, the imperfectly exposed Fort Benton and Niobrara, the finely exposed Fort Pierre, and finally before reaching the creek, finds himself on the Laramie sandstones. Thus far the dip has been *westward;* but immediately beyond the creek, the dip is reversed, so that before the low insignificant roll, separating the Arroyo de los Angeles from the Galisteo, is reached, the Laramie rocks are dipping *eastward* and almost vertical, thus forming a synclinal.

But on the opposite side of this low divide, the Lower Dakota sandstones are exposed and dip westward at 65°; at but a little way further westward are the variegated shales and the limestone of the Middle Dakota. On the west side of the Arroyo, the Lower Dakota rocks are dipping very sharply eastward, so that here too a synclinal exists. Thus there are two faults, one following the divide between the Arroyo and the creek, while the other follows the west side of the Arroyo,

whereby this fragment of Dakota has been thrust through the Laramie rocks. The two faults come together on the north side of lower Galisteo at the mouth of the Arroyo and the Dakota rocks do not cross the creek. The Colorado shales do not appear on either side of the faulted area.

But on the west side of this arroyo there appears a series, newer than any yet noticed. It covers the mesa stretching west and north from the Galisteo, and is continuous from the Santa Fe and Placer road on the lower Galisteo almost to the end of the Archean area on the upper Galisteo. This is the Galisteo group. As far as exposed within the area examined, which extends to but a little distance west and north from Galisteo creek, this group is

1. Breccia of trachyte..... 150 feet.
2. Soft, light gray sandstone.. 40 feet.

The breccia is well shown on the lower Galisteo from the Santa Fe and Old Placer road to the mouth of the Arroyo de los Angeles. It is exceedingly dark gray or even lead-colored and is composed altogether, where examined, of trachyte in angular fragments, cemented by finer material apparently of similar nature. This breccia was followed up the Arroyo to the Galisteo and Santa Fe road; but there it practically ends, and the evidence suggests that it was worn away by the erosion which produced the broad mesa. Its fragments litter the surface of that mesa. The thickness assigned this mass is that seen at the mouth of the Arroyo. It may be greater further toward the northwest.

The sandstone is very light gray, excessively soft and incoherent, so that it yields as readily to the weather as though it were loose sand, weathering indeed more freely than do the tough alluvial deposits along the creeks. This is the lowest bed of the group found within the area visited.

The relation of the Galisteo group to the underlying rocks is well shown at the head of the Arroyo, where the Dakota beds dip westward at 65°, while the lower sandstone of the Galisteo rests on their planed-off edges and dips in the same direction at less than one degree. A more curious illustration of the unconformability is shown immediately below the mouth of the Arroyo, where the breccia was deposited around a projecting wall of lower Dakota, which dips at nearly 60°; and the contrast in color is as great as that would be between a trachyte dike and a surrounding mass of basalt. Both the breccia and the underlying sandstone are exposed here and are conformable.

The Galisteo beds are not affected by the faults found in the Arroyo de los Angeles, whereas the Laramie beds are involved in them; the breccia is composed largely of trachyte from Los Cerillos, a group of hills, relics of dikes, shown on the north side of Galisteo creek at sixteen miles below the village. But

the outburst of trachyte, forming those hills, caused frightful distortion of the Laramie beds. It is clear, then, that the Galisteo group can not be conformable to the Laramie. The former group does not cross the Galisteo creek at any point.

The lower sandstone of the Galisteo group was followed up the creek for more than seven miles above Galisteo, and its ashen color gives a strange appearance to the deeply eroded face of the mesa. The vertical yellow and almost white sandstones of the Lower Dakota yield readily to the weather and the debris from the light gray Galisteo sandstone mingles with that from these; so that, to one ascending the creek and following the line of the eastern fault, the Galisteo sandstone seems to be triple, white, yellow and gray, whereas the white and yellow belong to the Lower Dakota, on which the Galisteo sandstone rests unconformably.

The coal beds of the Placer mountains, occupying the plateau between those mountains and Galisteo creek are synchronous with those of the Trinidad coal field and belong to what is known as the Laramie group, which, however, is synonymous, in part at least, with Fox Hills.

The Galisteo group rests unconformably on the Laramie and Dakota; and contains a great bed composed wholly of the later lavas; it is therefore Tertiary.

ART. LIX.—*Short Notes upon the Geology of Catoosa County, Georgia;* by A. W. VOGDES, U. S. Army.

A SHORT distance west of Catoosa Station, on the Western and Atlantic Railroad, we find a small cut which exposes the rocks of the Niagara period. This formation is composed in descending of the following strata:

1. Thin bed of limestone made up of crinoidal joints.
2. Cherty bed containing the columns of *Caryocrinus*.
3. Shaley beds with concretions.
4. Black slate containing about fifty per cent of bituminous matter.

This outcrop in the valley of the Chickamauga is not over ten feet in thickness and dips about twenty-five degrees to the east. A few hundred yards to the west along the river bank, the topography of the country becomes more hilly, and the railroad passes through a cut of about 100 feet. On the map of the county this is known as section 28, lot no. 204, or Taylor's Ridge. This section exposes an outcropping formation of the Upper Silurian Age which belongs to the Clinton

Epoch. The upper beds are thin and composed of an arenaceous limestone, containing fragments of Crinoids and shells more or less wave-broken, as if this stratum marked the line of the Clinton sea. Immediately beneath the limestone we find a laminated sandy bed intermixed with sandstone of different degrees of hardness, which is well exposed in the railroad cut and along the banks of the Chickamauga River. The total thickness of these beds is about 150 feet, the strata having a general dip 15° east.

The geological formation of Taylor's Ridge is more clearly defined with regard to the Upper Silurian age about ten miles southeast from Catoosa station, at Dug Gap in Whitfield county. This section exhibits the Lower Silurian black shales outcropping along the base of the gap, dipping about twenty-five degrees to the east, and known in Dalton as the "coal beds;" immediately above these shales the Medina sandstones appear or a sandstone which stratigraphically may be assigned to this group; as far as examined it contains no fossils. Superimposed upon these sandstones along the second bench of the Gap we find the Clinton, which is composed in descending order of the following strata:

1. Arenaceous layers and sandstone.
2. Hematitic layers containing *Calymene Clintoni*, *C. rostrata*, and generally trilobitic.
3. Arenaceous shales.
4. Sandstone containing *Streptorhynchus subplana.*
5. Hard sandstone containing hematite.
6. Light sandy beds of the Medina.

The best section examined is about twenty feet in thickness, but the measured thickness of the Clinton gives about 150 feet.

In order to illustrate the true geological sequence of Taylor's Ridge it is necessary to trace the different rocks from Atlanta to Ringgold, but at present we will simply give the section at Ringgold, which is about four miles to the west of our first section, taken near Catoosa station. The town of Ringgold is located in a valley composed of the Trenton limestone. This group is highly fossiliferous; it has a northwest and southeast strike, dips fifteen degrees to the east, being composed of a flinty rock, underlaid by a chocolate-colored shale, which is generally denuded; these shales are underlaid by a blue limestone of over three hundred feet in thickness. Superimposed and forming the hills is a great mass of red laminated sandstone of the Hudson River group. These sandstones are about five hundred feet in thickness, dip nineteen degrees east, one mile east of Ringgold in the gap, and contain only a few specimens of *Orthis testudinaria.*

Between Ringgold and Catoosa Station the Chickamauga river divides the ridge; the hills to the northwest are called Oak Mountains, and those on the southeast Taylor's Ridge. After passing through this gap the eastern exposure of these hills shows the overlying Medina, Clinton and Niagara groups.

The paleontological characteristics of this outcropping stratum of the Upper Silurian periods are interesting, especially the fossils of the upper beds. These fossils are poorly preserved and consist generally of casts. From our collection we have been enabled to indentify the following species:

Calymene Clintoni Hall; *Cryptonymus* (*Encrinurns*) *ornatus* Hall and Whitfield; *Cryptonymus* (*Encrinurus*), *Illænus*, *Proetus; Leperditia*, sp., having the right valve marginated by a furrow, except along the dorsal edge, as in *L. marginata; Othis elegantula*, a species common to the Clinton and Niagara group; *Chætetes lycoperdon*, cast from the lower beds; *Zaphrentis bilateralis?*, broken specimens from the upper bed; *Conularia*, sp.?

Of the *Cryptonymus ornatus* we have in our collection two pygidia which we have assigned to this species, although the casts do not show the nodes ornamenting the axis and pleuræ. The specimens compare otherwise with Professor Hall's type given in Palæontology of New York, vol. ii, pl. lxvi*a*, fig. 1*a*. Vertical distribution Clinton group.

There is also a new trilobite, *Calymene rostrata* Vodges, from the upper arenaceous limestone beds of the Clinton group, Catoosa Station, Georgia, which will be fully described hereafter. It differs from all other species of this genus in having a distinct projecting process in front of the glabella. The facial lines cut the anterior border at the apex, giving to the frontal limb a triangular form; at their juncture the marginal border is raised and forms the triangular process which supports the projection.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Electrolysis with Alternating Currents.*—Supposing that certain chemical transformations in the living organism are due, not to reduction or oxidation alone, but to both combined, Drechsel has devised a method for subjecting a liquid to reduction and oxidation in rapidly alternating succession. For this purpose, the electrodes of a Grove battery of 4 to 6 cells are placed in the solution, an automatic commutator being included in the circuit, so as to reverse the current rapidly. Each electrode thus becomes alternately positive and negative, first oxygen and then hydrogen being alternately evolved on its surface in the nascent state, each exerting its special action upon the dissolved substance. The

first solution experimented with was one of ammonium carbonate, the same as is used as a reagent. The electrodes were of platinum. Gas was actively evolved, the temperature rose, and after eight hours the experiment was interrupted and the liquid was evaporated on the water bath. From it a salt crystallized out in beautiful white needles. On analysis it was found to contain 64·69 per cent of platinum and was evidently a salt of a platinum base. The small quantity prevented complete investigation; though its solution gave with concentrated hydrochloric acid a bright green and with nitric acid a sky-blue crystalline precipitate. The electrodes lost in ten hours 0·1 gram; while when the electrolysis was conducted with a continuous current in the ordinary way, no platinum at all could be detected in the solution and at most only 0·002 gram had been transported from the anode to the cathode. On repeating the experiment with a less rapid alternation of the current, the liquid became warm, but gave no precipitate; on cooling it, however, during the experiment, an abundant crystalline precipitate was formed, which though also a salt of a platinum base, contained only 38·6 per cent of platinum, and gave with hydrochloric acid, not a green but a colorless crystalline powder consisting of microscopic needles. Finally, a solution of grape sugar mixed with sodium phosphate was submitted to alternating electrolysis, using platinum electrodes of large size, contact being prevented by a disk of filter paper between them. At the close of the experiment, there was formed on the platinum, at the place where the paper had rested against it, a brownish, transparent crust, easily separated into plates, and which left on combustion a considerable amount of platinum. The author is continuing his experiments upon this new method.

In a note to this paper, KOLBE says that the highly interesting observations of Drechsel raise the question of the behavior of salts and salt-solutions of inorganic and organic acids in presence of powerful and alternating voltaic currents; as, for example, whether an aqueous solution of potassium acetate suffers decomposition without accompanying oxidation. Since Drechsel does not purpose to extend his studies in this direction, Kolbe intends to examine the action of a series of salts under these conditions.—*J. pr. Ch.*, xx, 378, Oct., 1879. G. F. B.

2. *On the Basicity of Dithionic or Hyposulphuric Acid.*—It has been generally assumed that hyposulphuric acid is dibasic and hence that its formula is $H_2S_2O_6$. KOLBE has written it in his Lehrbuch $\left\{\begin{matrix}SO_2OH\\SO_2OH\end{matrix}\right.$ or di-sulphoxyl, as oxalic acid is $\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.$ or di-carboxyl. If this view be true, hyposulphuric acid should form, not only normal salts, but also acid, and mixed salts. Kolbe has set several of his students at work to endeavor to form either an acid salt or a mixed salt, an ether acid or an amic acid, of hyposulphuric acid, but without effect. Since all these bodies are readily given by oxalic acid, Kolbe comes to the conclusion that hyposulphuric acid is monobasic and contains but one hydroxyl

group. Hence the formula of it should be HSO_3 or $(SO_2)OH$. The importance of this conclusion lies in this, that, if it be conceded, the equivalence of sulphur is five in this compound and it becomes a perissad instead of an artiad as it is in all other combinations.—*J. pr. Ch.*, xix, 485, June, 1879. G. F. B.

3. *On the Non-existence of Pentathionic acid.*—In the hope of converting the polythionic acids into a new series of sulphur acids poorer in oxygen, SPRING submitted them to the action of sodium amalgam. But instead of the result expected a very different one was obtained. The sodium inserted itself between the sulphur atoms, splitting the molecule into two simpler ones; just as oxalic acid is converted by hydrogen into formic acid. For example, with tetrathionate, $KO_3SS.SSO_3K+Na_2=KO_3SSNa+NaSSO_3K$; with trithionate, $KO_3S.SSO_3K+Na_2=KO_3SNa+NaSSO_3K$; with dithionate $KO_3S.SO_3K+Na_2=KO_3SNa+NaSO_3K$. Precisely as $HO_2C.CO_2H+H_2=HO_2C.H+H.CO_2H$. In order to test this reaction in the case of pentathionic acid, the author attempted the preparation of this body; but after five months of work he was unable to obtain it. This result raised the question of the existence of this acid. All attempts to prepare it, by the method either of Wackenroder or of Fordos and Gelis resulted only in the production of tetrathionic acid. The action of hydrogen sulphide upon sulphurous oxide in aqueous solution produces hyposulphurous acid; and this is oxidized as it is formed into tetrathionic acid by the sulphurous acid present, the hydrosulphurous acid of Schutzenberger being formed at the same time. Pentathionic acid, therefore, appears to be as yet unknown.—*Liebig's Ann.*, cxcix, 97, Oct., 1879. G. F. B.

4. *On the Atomic Weight of Tellurium.*—WILLS has undertaken a re-determination of the atomic weight of tellurium, in order to ascertain whether the value of this constant as at present accepted from the experiments of Berzelius and von Hauer, or the value assumed for it in Mendelejeff's classification, is the more correct. The crude tellurium was purified by fusion with sodium carbonate and sulphur, the fusion extracted with boiling water, the filtrate acidulated with acetic acid, the precipitate well washed, oxidized with nitric acid, evaporated to dryness, heated with hydrochloric acid, the tellurium precipitated by sodium sulphite, washed, dried, fused with potassium cyanide, the fusion treated with water and the deep-claret solution exposed to the air in a flask when the tellurium separates in long needle-shaped crystals. After washing and careful drying these were distilled in a current of hydrogen. The distilled water, nitric and hydrochloric acid used were carefully purified and the accuracy of the weights and balance employed verified. On oxidizing the tellurium with nitric acid, and calculating the atomic weight from the TeO_2 obtained, the mean of five experiments gave 127·8 with a probable error of 0·32. Four experiments on oxidation with equa regia gave 127·907 with a probable error of 0·053. Five determinations by von Hauer's method, of the bromine in the compound K_2TeBr_6, gave Te =

126·83 with a probable error of 0·198. Hence the atomic weight of tellurium is essentially that obtained by Berzelius and von Hauer, and is higher than that of iodine, after which in Mendelejeff's system it should be placed, instead of between iodine and antimony.—*J. Ch. Soc.*, xxxv, 704, Oct., 1879. G. F. B.

5. *On the Preparation of Propylene glycol from Glycerin.*—A very convenient method has been proposed by BELOHOUBEK, for the direct preparation of propylene-glycol from glycerin. When glycerin is mixed with sodium amalgam in the proportion of one molecule of glycerine to one atom of sodium, and gradually warmed, a gummy mass results which, according to Letts, consists chiefly of monosodium glycerate. On submitting this to distillation, water and gas are at first evolved, then there comes over a colorless liquid readily miscible with water, and a brown strongly smelling liquid, lighter than water. The colorless liquid fractionated gave a product boiling at 186°–188°, having a weak odor like allyl, a burning taste, removable by agitation with ether, and on analysis the formula of propylene glycol. Its specific gravity at 0° C., was 1·054, its vapor density 2·68. With hydrochloric acid, it formed a chlorhydrin, which by the action of caustic potash gave propylene oxide. The yield was about 16 per cent of that required by theory. That the action here is due to the sodium of hydrate formed, was proved by distilling equal molecules sodium hydrate and glycerin. Nine per cent of the theoretical yield was obtained.—*Ber. Berl. Chem. Ges.*, xii, 1872, Oct., 1879. G. F. B.

6. *On Skatol.*—In his researches on the volatile substances contained in human feces, BRIEGER isolated a series of bodies belonging, some to the fatty and others to the aromatic class. The principal aromatic product of the decomposition of albumen in the intestinal canal, is a substance resembling indol to which he has assigned the name skatol. It crystallizes in brilliant white plates and posesses an intense fecal odor. It fuses at 93·5°, and is difficultly soluble in water. Warmed with dilute hydrochloric or nitric acid, it gives a violet color. Analysis gives it the formula C_9H_9N, its vapor density being 65·2. Blood-albumen, digested with pancreas and water at 36° C. for six to ten days, yields skatol on distillation. Two and a half kilograms albumen gave one gram of skatol.—*Ber. Berl. Chem. Ges.*, xii, 1985, Oct., 1879. G. F. B.

7. *On the Synthesis of Lactose.*—DEMOLE has succeeded in effecting a partial synthesis of milk-sugar, accomplishing an important step toward its complete synthetical production. Starting from the octacetyl-diglucose of Schutzenberger, which is isomeric and not identical with octacetyl-saccharose, the author, assuming that the glucose molecules of both saccharose and lactose are different, sought, by combining levulose and dextrose to produce saccharose and by uniting galactose with lactoglucose to produce lactose. Comparing octacetyl-diglucose with octacetyl-saccharose, they were found to have some points of difference, in solubility,

in rotatory power, and in their reactions, the former yielding diglucose, the latter cane-sugar. By the action of dilute acids upon lactose, two isomeric bodies, galactose and lactoglucose are produced. After removal of the acid, the product of this reaction was evaporated and carefully dried. It had all the properties of a mixture. It was mixed with three parts of acetic oxide, and heated to boiling until complete solution resulted. On treatment with water, a gelatinous ether resulted having the properties of octacetyl-lactose. On saponification by pouring the alcoholic solution of the synthesized ether into baryta water at 90°, and heating, there was obtained, on neutralizing and evaporating to dryness, and recrystallizing, a substance having all the properties of lactose, crystallizing in the orthorhombic system, and having a rotation $(\alpha)_D = +56{\cdot}7°$. On heating to 140°–145°, it afforded an anhydride.—*Ber. Berl. Chem. Ges.*, xii, 1935, Oct., 1879.

G. F. B.

II. Geology and Natural History.

1. *Report of the Geological Survey of Canada*, for 1877–78, Alfred R. C. Selwyn, Director. 8vo. Montreal, 1879. (Dawson Brothers).—This volume contains a wide range of geological observations, and is a very valuable contribution to the science. It includes a Report on the Quebec group by Mr. Selwyn; on Southern British Columbia (173 pages) by G. M. Dawson; with an Appendix on the Fossil Insects, by S. H. Scudder, and on Tertiary plants, by Dr. Dawson; on the East coast of Hudson Bay, and on the country between this Bay and Lake Winnepeg, by R. Bell; on New Brunswick Geology, by R. W. Ells, L. W. Bailey, and G. F. Mathew; on Cape Breton, N. S., by H. Fletcher; on minerals of the Apatite-bearing veins of Ottawa, with notes on miscellaneous rocks and minerals, by B. J. Harrington; on Canadian Apatite, by C. Hoffmann; and is illustrated by many sketches, sections and maps.

Mr. Selwyn divides the Quebec series of Logan into three groups: "(1.) The Lower Silurian group," containing fossils; "(2.) The Volcanic group, probably Lower Cambrian." "(3.) The Crystalline Schist group (Huronian?)." The evidence of a general volcanic origin of the second group is not stated. The kinds of rocks mentioned:—"thick-bedded feldspathic, chloritic, epidotic and quartzose sandstones, red, gray and greenish siliceous slates and argillites, great masses of dioritic, epidotic and serpentinous breccias and agglomerates, diorites, dolerites, and amygdaloids holding copper ores, serpentinous felsites, and some fine-grained granitic and gneissic rocks, also crystalline dolomites and calcites," make a remarkable assemblage to be spoken of as "these volcanic rocks." They were, for the most part, included in the Sillery sandstone formation by Logan. The account of the Quebec group is followed by the statement that, "in view of the usual associations of Labrador feldspars," (referring here to their

occurring as a constituent of some igneous rocks) "the labradorite or anorthosite" rocks of the Adirondacks and British America, probably "represent the *volcanic* and intrusive rocks of the Laurentian period."

These conclusions as to volcanic rocks make the mineral labradorite, and some others, settle a great question that should be settled by geological investigation; for we rightly ask that volcanic origin should be proved by the presence of obvious volcanic or eruptive conditions. What there is in a lime-and-soda feldspar to make its presence proof of eruptive origin, or of the existence of great volcanoes in a region that shows no other evidence of it, no one has pointed out. Lime is an exceedingly common material in sediments; and soda or sodium is present in other feldspars, and, in the state of chloride, abounds in sea water and occurs in salines and beds of rock-salt in strata of various ages. Moreover, the mineral labradorite, certainly does occur as a chief constituent in some metamorphic rocks that have nothing of volcanic origin in their constitution, as the writer has shown to be true in the vicinity of New Haven, Connecticut. So with felsyte, a rock made up of common feldspar or orthoclase, with often quartz—its composition is not sufficient evidence of an igneous or volcanic-ash origin.

Announcements on such evidence, of the former existence of volcanoes in a region, belong, in the writer's view, only to fancy-sketches.

The rocks of Mr. Selwyn's volcanic series were, for the most part, pronounced metamorphic by Logan, one of the best of geologists; and the list above given seems to show that Logan was, in all probability, right in this respect, whatever may be the fact as to the relative position of the Sillery sandstone and the fossiliferous beds of the Quebec group. The facts afforded by the Green Mountain region to the south in Vermont and Massachusetts, brought out by Mr. Wing and the writer, bear on the latter question.

In the course of Mr. Selwyn's paper on the Quebec group, he makes the just remark: that the names Norian, Montalban, Taconian and Keweenian, "applied to pre-Cambrian formations," serve no useful purpose; these representing "simply groups of strata which occupy the same geological interval and present no greater differences in their physical and mineralogical characters than are commonly observed to occur in formations of the same epoch in widely separated regions." "No better instances of such difference could be cited than the Mesozoic and Carboniferous formations of British Columbia, and those of the same periods in Eastern America and the Silurian and Cambrian formations of Australia, Europe and America."

Mr. G. M. Dawson's report contains a large amount of important information, both geological and economical. With regard to the drift of the interior of Columbia, he says that glacial markings occur up to a height of 5,280 feet on Iron Mountain; that, in the early part of the Glacial era, a great glacier, confluent

with that of the coast, covered probably the interior of the Province, which may have been 2,000 feet thick; that the regions of greatest precipitation and height of the ice was north of the 54th parallel; that it is "highly probable" that that part of the Pacific coast stood at an elevation greater than at present in times immediately preceding the Glacial, and "may have retained this altitude" during the era of the great confluent glacier. He adds, with an expressed questioning, "If I am right in attributing the flooding of the interior to the sea, we find a rapid subsidence of the land coincident with the decay of these vast glaciers;" and then speaks of a *second* short advance of the glaciers on the plateau from the mountains. No evidence of the presence of the sea in fossils or other decisive facts is presented.

Mr. R. Bell states, that on the east coast of Hudson Bay there is "abundant evidence that the sea-level is falling at a comparatively rapid rate;" that since the Posts of the Hudson Bay Company were established at the mouths of the various rivers, there has been an increasing difficulty in approaching them with large craft; that it amounts probably to between 5 and 10 feet a century. Mr. Bell states that this sinking is apparent also on the west coast of the bay at the mouth of the Nelson and Haye's Rivers; that an island, "Mile Lands," now several feet above high tide, was, "within the recollection of the generation preceding the present one, submerged at high tide." About the beginning of the present century vessels ventured in Ten-shilling Creek, which could not now approach its mouth. To the north of Lake Winnipeg, a region of lakes, the glacial scratches in general run southwestward, and the direction is mostly between S. 35° W. and S. 55° W.

The reports on New Brunswick have great interest from the relation of the rocks to those of Maine, and Mr. Mathew's, on the superficial geology of the Province, gives long lists of courses of glacial striæ, as well as other information respecting the Quaternary. These, and the following reports, contain much that would be cited here if space allowed. J. D. D.

2. *The Geological and Natural History Survey of Minnesota*, under N. H. WINCHELL, State Geologist. *7th Annual Report for the year* 1878. 123 pages, 8vo. Minneapolis, 1879.—The report contains a statement as to the work of the year, made brief in accordance with the action of the Board of Regents, which has ordered also that the survey be substantially completed in four years, and be followed by the publication of a Final Report of two volumes, one on the Northern part of the State, and the other on the Southern. The chief part of the volume is occupied with a paper by C. L. Herrick, on the Entomostraca of the State, which is illustrated by 20 plates. The writer recommended the publication of this paper as the report states; but he does not vouch for the correct determination of all the species. J. D. D.

3. *Brief Notices of some recently described Minerals.—Eggonite.* Observed by Schrauf in minute crystals, of a light brown color,

implanted upon crystals of calamine from Altenberg, near Aachen. The crystals bear some resemblance to certain simple forms of barite, but are in fact triclinic, though with a pseudo-monoclinic symmetry due to twinning. H.=4–5. In composition probably a silicate containing cadmium.—(*Zeitsch. Kryst.*, iii, 352).

Herrengrundite. Described by Brezina as a basic copper sulphate. It occurs in six-sided tabular crystals, belonging to the monoclinic (or triclinic) system, with perfect basal cleavage. H. = 2·5. Color dark emerald green. Associated with gypsum, malachite and calcite from Herrengrund (Urvölgy), Hungary (Zeitsch. Kryst., iii, 359). The same mineral was described about the same time by Szabó (Tsch. Min. Mitth., ii, 311) under the name Urvölgyite. He differs from Brezina in making the lime afforded by the analysis an essential constitutent of the mineral, while the latter regarded it as being due to the presence of gypsum.

Hofmannite. Occurs in colorless, tasteless, tabular crystals in lignite. Composition given by the formula $C_{20}H_{36}O$. Described by Bechi (Pisa).

Leucomanganite. A foliated and radiated snow-white mineral. Colorless in thin plates, but before the blowpipe becomes brownish-black and fuses easily. Chemical composition unknown; contains protoxides of iron and manganese, alkalies and water.—(*Sandberger, Jahrb. Min.*, 1879, 370.)

Louisite. A leek-green, translucent, vitreous mineral; brittle with splintery fracture. H. = 6·5. G. = 2·41. Gelatinizes in hydrochloric acid. An analysis by H. Louis afforded:

SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	H_2O
63·74	0·57	1·25	tr	17·27	0·38	0·08	3·38	12·96=99·63

From Blomidon, N. S.; named by D. Honeyman.

Reinite. A blackish-brown, opaque mineral, with sub-metallic luster. Observed in large crystals belonging to the tetragonal system. The composition is expressed by the formula $FeWO_4$. Discovered by Professor Rein in Kimbosan in Kei, Japan, named by K. v. Fritsch and described by Luedecke.—(*Jahrb. Min.*, 1879, 286.)

Plagiocitrite, Clinophœite, Wattevillite, Clinocrocite: Hydrous sulphates described by S. Singer as being identified by him at the Bauersberg, near Bischofsheim.

Bhreckite (Vreckite), *Xantholite, Abriachanite:* Names given provisionally by Heddle to substances "which may prove to be new Scottish minerals." Bhreckite is a chlorite-like mineral; xantholite has nearly the composition of staurolite, but is thought to be monoclinic in crystallization; abriachanite is an impure, bluish clay-like mineral.—(*Min. Mag.*, iii, 57, 1879.)

Haughtonite is, according to Heddle, a new mica. It has a jet black color, in thin plates transmitting a dark brown light. G. = 3·03. An analysis of material from hornblendic gneiss of Roneval afforded:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O
37·16	15·01	7·69	17·35	1·04	8·88	1·13	1·60	8·18	2·12=100·16

Analyses of a similar mica from other localities afforded results agreeing more or less closely with the above. Its claim for recognition as a species distinct from biotite and lepidomelane rests chiefly upon the relative proportion of the two oxides of iron.

4. *Ueber den Boracit* von H. BAUMHAUER.—Through an investigation of the etching figures produced on crystals of boracite by a dilute mixture of hydrochloric and sulphuric acids, Baumhauer has proved that the species belongs to the orthorhombic system. This conclusion was earlier reached by Mallard, but Baumhauer explains the occurring forms by a somewhat different and more simple method of twinning. The method of investigation employed is one which he has done much to develop, and which he has successfully applied to the solution of other similar problems.—(*Zeitsch. Kryst.*, iii, 337.)

5. *Genaue Messungen der Epidot-Krystalle aus der Knappenwand im oberen Sulzbachthal* von N. VON KOKSCHAROW, Sohn.—The already very extensive series of monographs devoted to the crystallization of epidote has been recently enlarged by an important memoir by N. von Kokscharow, the son of the great Russian mineralogist. This memoir contains the result of a large amount of careful work, including the measurement and calculation of the important angles of the occurring forms. The axial ratio and angle of inclination for the species are determined with a high degree of exactness that leaves nothing to be desired.

6. *Canadian Apatite;* by CHRISTIAN HOFFMANN (Geological Survey of Canada).—Mr. Hoffmann has analyzed a series of Canadian apatites; he shows that they all belong to the class of fluorapatites containing but a very small amount of chlorine. They are in general very free from impurity, as oxide of iron.

7. *Eucalyptographia: A Descriptive Atlas of the Eucalypts of Australia and the adjoining Islands;* by Baron FERDINAND VON MUELLER, K.C.M.G., F.R.S., etc. Decades 1 and 2, 4to, 1879. Melbourne and London. (Trübner, &c.).—It was a happy thought of the noted Australian botanist to describe anew and illustrate the species of *Eucalyptus*,—a thought long entertained, we are told, and at length undertaken under the patronage of the Victorian Government, and under conditions which promise success. For, in a country in which trees are of inestimable value, this genus comprises the principal timber-vegetation and is rich in other industrial products, while the species are very numerous, of very different economical importance and use, and almost throughout they are of difficult botanical limitation. Then Eucalyptus-trees are the sole rivals of the *Sequoias* of California in grandeur, appear in some cases to surpass them in height, and certainly exceed them in rapidity of growth. For the task in hand, even if economical considerations alone are taken into account, the indefatigable editor will certainly need, and ought freely to command, all the aids which can be afforded; but he complains, in the preface, that indispensable auxiliaries which he formerly controlled, have been withdrawn from the Government Botanist's department.

The complaint has reference to laboratory accommodation for technological investigation, and to the author's separation from the Botanic Garden, containing a large collection of growing trees which he had laboriously brought together. *Per contra*, let him consider how much valuable time he saves for true botanical work by his riddance from the multifarious cares which garden-superintendence involves.

In a work of this kind, which must needs take several years to finish, during which new species are sure to be discovered, and new information respecting the old ones is sure to come to light, the only practicable course is to bring out the illustrations without regard to scientific order, leaving them to be collected and systematically arranged at the completion of the undertaking. Consequently the figures and the letter-press are neither paged nor numbered. Both are in quarto form, a leaf (and commonly the whole of its two pages), as also a well-filled plate, being devoted to each species. The plates are well drawn, executed in good lithography, and contain fair dissections and not a little of microscopical detail. Some extra plates are given in illustration of the structure of the wood, and also of the anthers. To figure all the *Eucalypti* will require fourteen or fifteen decades; even then the work will be comparatively low-priced, for the decades are published at five shillings each. The book will have an interest beyond Australia, in all climates in which the cultivation of these trees may be hopefully attempted, such, for instance, as the south-western part of California. Indeed the mountain species might be tried on any part of our western coast, and some might be expected to withstand the occasionally severe cold of the districts bordering the Gulf of Mexico. A. G.

8. *Monographiæ Phanerogamarum Prodromi, nunc Continuatio, nunc Revisio* auctoribus ALPHONSO et CASIMIR DECANDOLLE. Vol. II, *Araceæ* auctore ENGLER. Paris: Masson, Sept., 1879. pp. 681.—This second volume of the supplement to the Prodromus is completely occupied by Dr. A. Engler, now Professor at Kiel, with his monograph of the order *Araceæ*. This great order Engler accepts in the largest sense, including the "*Pistioideæ*" (of *Pistia* only reduced to a single species), and the "*Lemnoideæ*" (*Spirodela, Lemna, and Wolffia*), these being ranked as the ninth and tenth sub-families of the order. The larger of the other sub-families divide into tribes and sub-tribes, and the genera are one hundred and one! A condensed account of the structure, distribution, and taxonomy of Araceous plants precedes the systematic portion, and a full index follows. There are no figures; but the author has illustrated the Brazilian species in the Flora Brasiliensis, and the structure and classification in the Acta of the Acad. Nat. Curiosorum. The genera and species of *Lemnaceæ* or *Lemneæ* (names surely to be preferred to "*Lemnoideæ*") are omitted, being the subject of a recent monograph by Hegelmaier. Under the habitat the country is cited, and then the specimens which have come under the author's observation, with their source. A. G.

9. *Anatomie Comparée des Feuilles chez quelques Familles de Dicotylédones;* par M. CASIMIR DECONDOLLE. A memoir separately issued from the *Mem. Soc. Phys.* and *Hist. Nat. de Genève*, tome xxvii, partie 2. 1879. pp. 427–480, and two plates, 4to.—One of Cassimir DeCandolle's earliest studies was into the structure and relations of the fibro-vascular elements of the leaf, and the results and deductions were brought out in his brief article entitled Theorie de la Feuille, in the year 1858. The present paper is in no respect theoretical, nor does it investigate the minute anatomy and formation of the vascular bundles. But it presents a comparative view of the general structure of the woody system of the petiole and principal veins in a very considerable number of Dicotyledons, mainly trees, and belonging to different natural orders. In this way the nature of the principal differences from species to species, and from one order to another, are brought to view, and the taxonomical value of such characters indicated. It is found that different species of the same genus sometimes accord, but sometimes differ notably in this part of their anatomy. Wherefore the classificatory importance of these differences is low, yet they may often be turned to good account in the discrimination of related species. The essential fibro-vascular system of the petiole, as displayed on a cross-section, forms either a closed ring or an arc open superiorly between the outer or cortical and the inner or medullary tissue; in the first case it is said to be closed or complete, in the second open or incomplete. Very commonly this is the only vascular system of the petiole, ribs, or veins. Not rarely there are additional or accessory bundles, sometimes external to the essential system, or *intracortical;* sometimes within the arc or ring, or *intramedullary;* occasionally there are both intracortical and intramedullary bundles. Generally plants of the same order will agree, at least approximately, in having the closed or open system, and in having or wanting the accessory bundles without or within. But, while *Acer Pseudo-platanus* has a well developed intramedullary cord, *A. platanoides* has none, and in general the Maples are divided in this respect quite independent of other characters; and the difference is similar and equally marked between the species of *Æsculus.* The oaks, which have been made a special study in this regard, appear to be somewhat equally divided between species provided with and those destitute of intramedullary bundles; but related species generally belong to the same category, yet not always. For in one case two species, of doubtful distinction until now, are confirmed by the discovery of an anatomical difference of this sort. All the Birches examined want the intracortical bundles and the principal system forms an open arc, and one or two Alders nearly agree with them; while the others have a closed ring and are furnished with intracortical bundles. The two plates contain about thirty accurately drawn and carefully engraved figures of sections, moderately magnified. A. G.

10. *Bentham and Hooker's Genera Plantarum.*—It is known to Botanists generally that the first part of the third (and concluding)

volume of this important work is passing through the press. We are informed that this part, which will complete the *Dicotyledones*, will be published in London at the close of the year. It is known to many of his correspondents that the present writer has arranged, by taking a considerable number of copies to secure this work for American botanists, or the public libraries with which some of them are connected, at a reduced price. As his own lists of those who have hitherto received the work through his mediation may not be complete, all those who wish to obtain the new part in this way are requested to communicate with him upon the subject without delay. A. G.

11. *Chesapeake Zoological Laboratory; Johns Hopkins University*, Baltimore, Md. *Scientific Results of the Session* of 1878 (June 24th to August 19th.) 170 pp. 8vo, with 13 plates. Baltimore: 1879.—This volume, issued under the auspices of the Johns Hopkins University, contains, besides lists of land plants and animals found at Fort Wool, the following important zoological papers: Development of Lingula, Development of Gasteropods, and Development of Squilla, with 12 plates, by W. K. Brooks; *Lucifer typus*, by W. Faxon, with 1 plate; and Early stages of Amphioxus, by H. J. Rice, with 2 plates.

III. Astronomy.

1. *The Minor Planets, arranged in the order of their numbers;* by Aaron N. Skinner. (Communication to the Editors, dated Naval Observatory, Washington, October 4.)

No.	Name.	Discoverer.	Disc. No.	No.	Name.	Discoverer.	Disc. No.
1	Ceres	Piazzi		20	Massalia	DeGasparis	6
2	Pallas	Olbers	1	21	Lutetia	Goldschmidt	1
3	Juno	Harding		22	Calliope	Hind	7
4	Vesta	Olbers	2	23	Thalia	Hind	8
5	Astræa	Hencke	1	24	Themis	DeGasparis	7
6	Hebe	Hencke	2	25	Phocæa	Chacornac	1
7	Iris	Hind	1	26	Proserpina	Luther	2
8	Flora	Hind	2	27	Euterpe	Hind	9
9	Metis	Graham		28	Bellona	Luther	3
10	Hygeia	DeGasparis	1	29	Amphitrite	Marth	
11	Parthenope	DeGasparis	2	30	Urania	Hind	10
12	Victoria	Hind	3	31	Euphrosyne	Ferguson	1
13	Egeria	DeGasparis	3	32	Pomona	Goldschmidt	2
14	Irene	Hind	4	33	Polyhymnia	Chacornac	2
15	Eunomia	DeGasparis	4	34	Circe	Chacornac	3
16	Psyche	DeGasparis	5	35	Leucothea	Luther	4
17	Thetis	Luther	1	36	Atalante	Goldschmidt	3
18	Melpomene	Hind	5	37	Fides	Luther	5
19	Fortuna	Hind	6	38	Leda	Chacornac	4

No.	Name.	Discoverer.	Disc. No.	No.	Name.	Discoverer.	Disc. No.
39	Lætitia	Chacornac	5	85	Io	Peters	4
40	Harmonia	Goldschmidt	4	86	Semele	Tietjen	
41	Daphne	Goldschmidt	5	87	Sylvia	Pogson	6
42	Isis	Pogson	1	88	Thisbe	Peters	5
43	Ariadne	Pogson	2	89	Julia	Stephan	
44	Nysa	Goldschmidt	6	90	Antiope	Luther	15
45	Eugenia	Goldschmidt	7	91	Aegina	Borrelly	1
46	Hestia	Pogson	3	92	Undina	Peters	6
47	Aglaja	Luther	6	93	Minerva	Watson	2
48	Doris	Goldschmidt	8	94	Aurora	Watson	3
49	Pales	Goldschmidt	9	95	Arethusa	Luther	16
50	Virginia	Ferguson	2	96	Aegle	Coggia	1
51	Nemausa	Laurent		97	Clotho	Tempel	5
52	Europa	Goldschmidt	10	98	Ianthe	Peters	7
53	Calypso	Luther	7	99	Dike	Borrelly	2
54	Alexandra	Goldschmidt	11	100	Hecate	Watson	4
55	Pandora	Searle		101	Helena	Watson	5
56	Melete	Goldschmidt	12	102	Miriam	Peters	8
57	Mnemosyne	Luther	8	103	Hera	Watson	6
58	Concordia	Luther	9	104	Clymene	Watson	7
59	Elpis	Chacornac	6	105	Artemis	Watson	8
60	Echo	Ferguson	3	106	Dione	Watson	9
61	Danaë	Goldschmidt	13	107	Camilla	Pogson	7
62	Erato	Förster		108	Hecuba	Luther	17
63	Ausonia	DeGasparis	8	109	Felicitas	Peters	9
64	Angelina	Tempel	1	110	Lydia	Borrelly	3
65	Cybele	Tempel	2	111	Ate	Peters	10
66	Maja	H. P. Tuttle	1	112	Iphigenia	Peters	11
67	Asia	Pogson	4	113	Amalthea	Luther	18
68	Leto	Luther	10	114	Cassandra	Peters	12
69	Hesperia	Schiaparelli		115	Thyra	Watson	10
70	Panopæa	Goldschmidt	14	116	Sirona	Peters	13
71	Niobe	Luther	11	117	Lomia	Borrelly	4
72	Feronia	C.H.F.Peters	1	118	Peitho	Luther	19
73	Clytia	Tuttle	2	119	Althæa	Watson	11
74	Galatea	Tempel	3	120	Lachesis	Borrelly	5
75	Eurydice	Peters	2	121	Hermione	Watson	12
76	Freia	D'Arrest		122	Gerda	Peters	14
77	Frigga	Peters	3	123	Brunhild	Peters	15
78	Diana	Luther	12	124	Alceste	Peters	16
79	Eurynome	Watson	1	125	Liberatrix	Prosp.Henry	1
80	Sappho	Pogson	5	126	Velleda	Paul Henry	1
81	Terpsichore	Tempel	4	127	Johanna	Prosp.Henry	2
82	Alcmene	Luther	13	128	Nemesis	Watson	13
83	Beatrix	DeGasparis	9	129	Antigone	Peters	17
84	Clio	Luther	14	130	Electra	Peters	18

No.	Name.	Discoverer.	Disc. No.	No.	Name.	Discoverer.	Disc. No.
131	Vala	Peters	19	171	Ophelia	Borrelly	8
132	Aethra	Watson	14	172	Baucis	Borrelly	9
133	Cyrene	Watson	15	173	Ino	Borrelly	10
134	Sophrosyne	Luther	20	174	Phaedra	Watson	20
135	Hertha	Peters	20	175	Andromache	Watson	21
136	Austria	Palisa	1	176	Idunna	Peters	27
137	Meliboea	Palisa	2	177	Irma	Paul Henry	6
138	Tolosa	Perrotin	1	178	Belisana	Palisa	10
139	Juewa	Watson	16	179	Clytemnestra	Watson	22
140	Siwa	Palisa	3	180	Garumna	Perrotin	5
141	Lumen	Paul Henry	2	181	Eucharis	Cottenot	
142	Polana	Palisa	4	182	Elsbeth	Palisa	11
143	Adria	Palisa	5	183	Istria	Palisa	12
144	Vibilia	Peters	21	184	Dejopeia	Palisa	13
145	Adeona	Peters	22	185	Eunike	Peters	28
146	Lucina	Borrelly	6	186	Celuta	Prosp. Henry	7
147	Protogeneia	Schulhof		187	Lamberta	Coggia	2
148	Gallia	Prosp. Henry	3	188	Menippe	Peters	29
149	Medusa	Perrotin	2	189	Phthia	Peters	30
150	Nuwa	Watson	17	190	Ismene	Peters	31
151	Abundantia	Palisa	6	191	Kolga	Peters	32
152	Atala	Paul Henry	3	192	Nausicaä	Palisa	14
153	Hilda	Palisa	7	193	Ambrosia	Coggia	3
154	Bertha	Prosp. Henry	4	194	Prokne	Peters	33
155	Scylla	Palisa	8	195	Eurykleia	Palisa	15
156	Xanthippe	Palisa	9	196	Philomela	Peters	34
157	Dejanira	Borrelly	7	197	Arete	Palisa	16
158	Coronis	Knorre		198	Ampella	Borrelly	11
159	Aemilia	Paul Henry	4	199	Byblis	Peters	35
160	Una	Peters	23	200	Dynamene	Peters	36
161	Athor	Watson	18	201	Penelope	Palisa	17
162	Laurentia	Prosp. Henry	5	202	Chryseïs	Peters	37
163	Erigone	Perrotin	3	203	Pompeia	Peters	38
164	Eva	Paul Henry	5	204		Palisa	18
165	Loreley	Peters	24	205		Palisa	19
166	Rhodope	Peters	25	206	Hersilia	Peters	39
167	Urda	Peters	26	207		Palisa	20
168	Sibylla	Watson	19	208		Palisa	21
169	Zelia	Prosp. Henry	6	209	Dido	Peters	40
170	Maria	Perrotin	4				

ALPHABETICAL INDEX OF THE MINOR PLANETS.

No.	Name.	No.	Name.	No.	Name.	No.	Name.	No.	Name.
151	Abundantia	53	Calypso	79	Eurynome	3	Juno	201	Penelope
145	Adeona	107	Camilla	27	Euterpe	191	Kolga	174	Phaedra
143	Adria	114	Cassandra	164	Eva	120	Lachesis	196	Philomela
91	Aegina	186	Celuta	109	Felicitas	39	Laetitia	25	Phocæa
96	Aegle	1	Ceres	72	Feronia	187	Lamberta	189	Phthia
159	Aemilia	202	Chryseïs	37	Fides	162	Laurentia	142	Polana
132	Aethra	34	Circe	8	Flora	38	Leda	33	Polyhymnia
47	Aglaja	84	Clio	19	Fortuna	68	Leto	32	Pomona
124	Alceste	97	Clotho	76	Freia	35	Leucothea	203	Pompeia
82	Alcmene	104	Clymene	77	Frigga	125	Liberatrix	194	Prokne
54	Alexandra	179	Clytemnestra	74	Galatea	117	Lomia	26	Proserpina
119	Althæa	73	Clytia	148	Gallia	165	Loreley	147	Protogeneia
113	Amalthea	58	Concordia	180	Garumna	146	Lucina	16	Psyche
193	Ambrosia	158	Coronis	122	Gerda	141	Lumen	166	Rhodope
198	Ampella	65	Cybele	40	Harmonia	21	Lutetia	80	Sappho
29	Amphitrite	133	Cyrene	6	Hebe	110	Lydia	155	Scylla
175	Andromache	61	Danaë	100	Hecate	66	Maja	86	Semele
64	Angelina	41	Daphne	108	Hecuba	170	Maria	168	Sibylla
129	Antigone	157	Dejanira	101	Helena	20	Massalia	116	Sirona
90	Antiope	184	Dejopeia	103	Hera	149	Medusa	140	Siwa
197	Arete	78	Diana	121	Hermione	137	Meliboea	134	Sophrosyne
95	Arethusa	99	Dike	206	Hersilia	56	Melete	87	Sylvia
43	Ariadne	209	Dido	135	Hertha	18	Melpomene	81	Terpsichore
105	Artemis	106	Dione	69	Hesperia	188	Menippe	23	Thalia
67	Asia	48	Doris	46	Hestia	9	Metis	24	Themis
5	Astræa	200	Dynamene	153	Hilda	93	Minerva	17	Thetis
152	Atala	60	Echo	10	Hygeia	102	Miriam	88	Thisbe
36	Atalante	13	Egeria	98	Ianthe	57	Mnemosyne	115	Thyra
111	Ate	130	Electra	85	Io	192	Nausicaä	138	Tolosa
161	Athor	59	Elpis	176	Idunna	51	Nemausa	160	Una
94	Aurora	182	Elsbeth	173	Ino	128	Nemesis	92	Undina
63	Ausonia	62	Erato	112	Iphigenia	71	Niobe	30	Urania
136	Austria	163	Erigone	14	Irene	150	Nuwa	167	Urda
172	Baucis	181	Eucharis	7	Iris	44	Nysa	131	Vala
83	Beatrix	45	Eugenia	177	Irma	171	Ophelia	126	Velleda
178	Belisana	185	Eunike	42	Isis	49	Pales	4	Vesta
28	Bellona	15	Eunomia	190	Ismene	2	Pallas	144	Vibilia
154	Bertha	31	Euphrosyne	183	Istria	55	Pandora	12	Victoria
123	Brunhild	52	Europa	127	Johanna	70	Panopæa	50	Virginia
199	Byblis	75	Eurydice	139	Juewa	11	Parthenope	156	Xanthippe
22	Calliope	195	Eurykleia	89	Julia	118	Peitho	169	Zelia

2. *Annals of the Astronomical Observatory of Harvard College.* Vol. xi, Part I, Photometric Observations made principally with the equatorial telescope of fifteen inches aperture during the years 1877–79, by EDWARD C. PICKERING, Director, aided by Arthur Searle and Winslow Upton, Assistants in the Observatory. 189 pp. 4to. Cambridge, 1879 (University Press: John Wilson & Son).—The subject of Photometry is that to which the large equatorial of the Harvard Observatory has been devoted since the summer of 1877. The observations necessitated the invention and construction of a new class of instruments, which are described in the first chapter of the volume. Chapter II is devoted to

the journal containing the photometric observations made from August, 1877, to September, 1878, and in part those of October, 1878, to March, 1879; these are numbered from 1 to 5037. Chapter III contains the reduction of the observations of Saturn and Mars, and of Jupiter and Venus at their conjunctions in 1877; and chapter IV contains the discussion of the observations made on the more conspicuous double stars visible in the latitude of Cambridge. This work is one of especial importance because it is the first time that so large an instrument has been entirely devoted to Photometry.

IV. Miscellaneous Scientific Intelligence.

1. *Geological Survey of the Public Domain.*—In volume xvii of this Journal, at page 78 (January number, 1879), the Report of the Committee of the National Academy of Sciences "appointed to consider the Scientific Surveys of the United States" which had been required of the Academy by an act of Congress, is published at length. The Report recommended two distinct departments with reference to such surveys, under separate heads—one for Surveys of Mensuration (to include the Coast and Geodetic surveys, and the topograpical work of the Land Survey office, and the other, for "the determination of all questions relating to the Geological structure and Natural Resources of the Public Domain."

With regard to the latter the report says, "in view, especially of the value of such surveys to the Land Office:"—

"The best interests of the Public Domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources and products. The domain embraces vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert and swamp lands, a thorough investigation and classification of the acreage of the Public Domain is imperatively demanded. The Committee therefore recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the Public Domain; such a survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior."

The Report, having been submitted to Congress, was favorably acted upon on March 3d, as regards the second of the two departments recommended in the Report; and, as the passage of the bill is an important event in the history of American scientific surveys, the portion of the Act "making appropriations to Sundry Civil Expenses," which has reference to it, is here cited (pp. 20, 21).

"For the salary of the Director of the Geological Survey, which office is hereby established, under the Interior Department, who shall be appointed by the President by and with the advice and consent of the Senate, six thousand dollars: *Provided*, That this

officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the Geological Structure, mineral resources and products of the National Domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys West of the One hundredth Meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey, the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum.

"For the expenses of the Geological Survey and the classification of the public lands and examination of the Geological structure; mineral resources and products of the National Domain, to be expended under the direction of the Secretary of the Interior, one hundred thousand dollars;

"For the expense of a commission on the codification of existing laws relating to the survey and disposition of the Public Domain, and for other purposes, twenty thousand dollars;

"*Provided*, That the Commission shall consist of the Commissioner of the General Land Office, the Director of the United States Geological Survey, and three civilians, to be appointed by the President, who shall receive a per diem compensation of ten dollars for each day while actually engaged, and their traveling expenses; and neither the Commissioner of the General Land Office nor the Director of the United States Geological Survey, shall receive other compensation for their services upon said commission than their salaries, respectively, except their traveling expenses, while engaged on said duties; and it shall be the duty of this commission to report to Congress within one year from the time of its organization; first, a codification of the present laws relating to the survey and disposition of the public domain; second, a system and standard of classification of public lands; as arable, irrigable, timber, pasturage, swamp, coal, mineral lands and such other classes as may be deemed proper, having due regard to humidity of climate, supply of water for irrigation, and other physical characteristics; third, a system of land parcelling surveys adapted to the economic uses of the several classes of lands; and, fourth, such recommendations as they may deem wise in relation to the best method of disposing of the public lands of the western portion of the United States to actual settlers.

"The publications of the Geological Survey shall consist of the

annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials, received in exchange shall be the property of the United States and form a part of the library of organization: and the money resulting from the sale of such publications shall be covered into the Treasury of the United States, under the direction of the Secretary of the Interior; one hundred thousand dollars;

"For the preparation of reports, maps, and such other illustrations as may be necessary for completing the office work of the Geological and Geographical Survey of the Territories, twenty thousand dollars; to be immediately available.

"For the completion of the reports of the Geographical and Geological Survey of the Rocky Mountain Region with the necessary maps and illustrations, twenty thousand dollars; to be immediately available.

"For the preparation of reports, maps and such other illustrations as may be necessary for completing the office work of the Geographical Surveys West of the One hundredth Meridian, under the direction of the Secretary of War, twenty thousand dollars; to be immediately available."

The office of Director of the Geological Survey, "to have the direction of the Geological Survey, and the classification of the public lands, and examination of the geological structure, mineral resources and products of the *National Domain*," was thus established; and soon after, the position of Director of the Survey was given to Mr. Clarence King, who by long work in the field had already become well acquainted geologically with much of the National Domain over which his surveys were to extend.

The failure of Congress to act favorably with reference to the establishment of "Mensuration Surveys," recommended in the Report of the Committee of the Academy, is thought to be a deferring of the subject for the time, and not a rejection of the scheme.

Another move with regard to the department of the Geological Survey has been made since Mr. King received his appointment, and one which has not yet been laid before a Committee of the National Academy, and has not even been presented for public discussion, although it bears on the political and industrial interests of the country, as well as on the status of Science under the General Government.

The session of Congress, in which the Department of the Geological Survey of the Public Domain was established, was followed

by an extra session which closed on the 1st of July. The Congressional Record of the 29th of June reports that a resolution was introduced into the House of Representatives, adding after the words "National Domain" in the first paragraph of the former bill, the three words "and the States." (See the eighth line in this paragraph, on page 493). It says, further, that the resolution was discussed at length, and that, finally, an amendment passed the House, substituting, for the three words, the following—to be introduced at the same place: "and he may extend his examinations into the States." The resolution failed of being brought before the Senate for want of time.

With the words "and the States" inserted, the area geologically and economically under the Director's supervision becomes suddenly enlarged to the dimensions of the whole country from the Atlantic to the Pacific. The geological surveys of all the several States come under the control, and their prosecution is made the duty, of the General Government; and the work of exploring their mining and other resources, is also assumed by this new United States department. And this is the view which the Director takes of the amendment adopted by the House; for he personally informed the writer after the adjournment of Congress, that it was his purpose, under the act, to send a party into New England next spring.

Having been a member of the National Academy, the writer has felt it a duty here to state, that this proposed expansion of the field of work under the "Director of the Geological Survey" is wholly foreign to the views expressed in the Report of the Committee, and to the opinions brought out in their discussions. Moreover, it is entirely at variance with the objects set before the Committee by the Act of Congress requiring its appointment: this act asking that the members "take under consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost." The plan set forth by the Committee, besides having direct reference to the Territories, had in view that economy of expenditure, suggested in the act of Congress; while the new scheme, with the proposed enlargement of its scope, would involve—as State geological surveys have shown—millions of outlay for the strictly geological part, and indefinite millions besides for the economical branch—the study of "the mineral resources and products of the National Domain" "*and the States.*"

The writer is not informed as to the character of the discussion over the proposed amendment in the House of Representatives. But it seems to be plain, from the change of wording, that the meaning intended to be conveyed by it was that the Director "may extend his examinations into States" *which adjoin the*

Territories. There is an evident absurdity in an expression which adds the States—nearly the whole country—to the Territories. Had the general survey of the United States been intended by the House, the idea would have been brought out by the simple substitution of the words United States for "National Domain."

A change so great in the administration of the affairs of the Government should have a full discussion before it is accepted. It will appear to many that the Constitution has left to the States the making of their own geological surveys and the study of their own economical resources—as past history seems to attest—and that such an infringement on State rights and assumption of State responsibilities would be politically wrong; and also, that investigations into the mineral resources of the States, whether of a mine or of a granite quarry, would be followed by other evils through encroachments on private rights, and the temptations to favor private enterprises. The General Government, unlike many in foreign lands, has no ownership in the mines of California or of any other of the States, and hence has no need to establish a Mining Bureau for the country at large.

The States, for the most part, have carried forward geological surveys. The great need, previous to undertaking new surveys, in order that they may be correct and complete, is, for each, an accurate topographical survey. Before New England, or any part of this or of the other sections of the Union, has again its corps of geological surveyors, it should have in the field, for a number of years, corps of geodetic and topographical surveyors,—preparing maps in which roads, rivers, hills, mountains, State-lines, county-lines, town-lines, and all positions, are correctly given.

Within four years a scheme for the scientific survey of Connecticut has been brought before the legislature of the State by a committee which included the writer among its members. And this committee urged, in its petition, that, *first*, a topographical survey should be made in order that a satisfactory geological survey might be a possibility. It was manifest that without such a preparation the work would be half a waste of expenditure, and have to be done over again.

Topographical surveys are needed in every State as well as Territory; and for this purpose there is manifestly required the establishment of a Department of "Mensuration Surveys," under the General Government, whose geodetic work over the breadth of the country shall, in accordance with some well devised plan, be supplemented by topographical work at the expense, and under the united supervision, of the State and General Government. This done, the States could easily carry forward their own scientific and economical surveys. JAMES D. DANA.

2. *Chemical Denudation in relation to Geological Time;* by T. MELLARD READE. 62 pp. 8vo. London, 1879. (David Bogue.)—Mr. T. Mellard Reade gives, in his memoir, the results of his comparisons of the amount of denudation in various regions over

the globe, and of various considerations derived from the constitution of the earth's crust, the composition of river and sea waters and deep-sea and shallow-sea formations. He closes his volume with the conclusion that the minimum amount of time required to make the world's limestone strata is "in round numbers say 600,000,000 years;" and that this time is divided about equally between (1) the Silurian and Pre-silurian; (2) the rest of the Paleozoic ages and Triassic; and (3) the remainder of geological time. After all, this question of time geological science knows little about, beyond the general fact of its almost indefinite length.

3. *Report No. 2, of the Princeton Scientific Expedition of 1877: Topographic, Hypsometric and Meteorologic Report*, by W. Libbey, Jr., and W. W. McDonald. 56 pp. 8vo, with an Appendix of 28 pp. New York, 1879.—This Report contains geological as well as topographic information respecting the region visited by the Princeton Expedition, and has many beautiful "artotype" plates representing scenes in the mountain regions remarkable as illustrations of erosion and other geological phenomena. The height determined by the Expedition for Pike's Peak was 14,147·28 feet (made 14,146·56 by Hayden's expedition); for Mount Lincoln 14,297·80 (14,297·00 Hayden); for Mount Silverheels 13,861 (13,897 Hayden); for Mount Princeton 14,208·90 (14,196 Hayden, 14,041 Wheeler's Expedition); for Mount Evans 14,353·30 (14,340 Hayden); Mount Gray 14,363·30 (14,341 Hayden); Mount Bross, 14,255 feet; Mount Alma, 10,364·50 (10,254 Wheeler's Expedition).

4. *Lectures and Essays by the late William K. Clifford, F.R.S.*, edited by Leslie Stephen and Frederick Pollock; with an introduction by F. Pollock. In two volumes, 8vo. London, 1879. (Macmillan & Co.).—The sketch, which opens this work, was written by a personal friend of the late Professor Clifford, and hence one well able to speak of him. While not attempting to be a complete biography, it brings out clearly the prominent points in the mental character and the attainments of the gifted mathematician, whose work was so suddenly interrupted. The lectures and essays contained in these two volumes are for the most part of a philosophical rather than a strictly scientific character, and hence it lies outside of the province of this Journal to give an extended notice of them. They are characterized by the clear and vigorous thought which was shown in all the work of their author. It is well both for his sake and for that of the public that they have been preserved and presented in this form.

5. *Seeing and Thinking;* by the late William K. Clifford, F.R.S. 156 pp. 8vo. London. (Nature Series: Macmillan & Co.). —Four lectures delivered by Professor Clifford at Shoreditch; they bear the titles: the Eye and the Brain; the Eye and seeing; the Brain and thinking; of Boundaries in general. They contain many important scientific facts presented in so simple a manner and with such fullness of illustration as to be intelligible even to those who have had no scientific training.

6. *The Mound Builders; Archæology of Butler County, Ohio;* by J. P. MacLean. 234 pp. 8vo, illustrated with over 100 figures. Cincinnati. (Robert Clarke & Co.)—Two-thirds of this volume are devoted to the general subject of the mound builders, and give a well digested account of the observations and results hitherto obtained. The remainder is devoted to an account of the ancient earth-works and Indian relics of Butler County, in southwestern Ohio, a region containing more of such earth-works than any other county in the State; their number is seventeen, and one of them covers an area of 95 acres. Many figures are given representing stone arrow-heads, implements and ornaments, and also plans of the earth-works, besides an Archæological map of the county.

7. *Maps of the U. S. Geological and Geographical Survey of the Territories*, F. V. Hayden, Geologist-in-Charge.—Five maps of this Survey have recently been issued, 20 to 26 by 36 inches in size, illustrating the topography and geography of portions of Utah, Idaho and Wyoming territories, and they are remarkable for beauty of execution, while of great interest for the region they illustrate. The Primary triangulation in the survey was carried forward by A. D. Wilson, and the topography by H. Gannett, G. B. Chittenden, G. R. Bechler and F. A. Clark. These maps include a drainage map, a map of the Yellowstone National Park on a scale of two miles to an inch, and maps of other portions of the Territories named, giving the altitudes of numerous measured peaks, and by means of contour lines, the character of the various mountain ranges and plateaus, including the Wind River Mountains, the Bear River Range, the Teton Range, the Snake River Range, and others. The engraving is by J. Bien.

Notices of the following new works are deferred to another number:

Report on the Geology of the Henry Mountains, by G. K. Gilbert. 160 pp. 4to. U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell, in charge. Department of the Interior.

Pennsylvania Second Geological Survey. Harrisburg, 1879. (1.) Second Report of Progress in the Laboratory of the Survey at Harrisburgh, by Andrew S. McCreath. 438 pp. 8vo.—(2.) Report, Part first, on the Northern townships of Butler County; Part second, on a Special Survey along the Beaver and Shenango Rivers, by H. Martyn Chance. 248 pp. 8vo, with 6 maps, 1 profile section and 154 vertical sections.

A Manual of Palæontology for the use of students, with a general introduction on the principles of Palæontology, by Henry Allyn Nicholson, Prof. Nat. Hist. Univ. St. Andrews. Second edition, revised and greatly enlarged. 2 volumes, with numerous illustrations. 1879, Edinburgh and London. (Wm. Blackman & Sons.)

Geological Survey of Alabama, Report of Progress for 1877, 1878, by Eugene A. Smith, Ph.D., State Geologist. 140 pp. 8vo. Montgomery, Alabama, 1879.

Solar Light and Heat: the Source and the Supply. Gravitation with explanation of Planetary and Molecular Forces, by Zachariah Allen, LL.D. 241 pp. 8vo. New York, 1879. (D. Appleton & Co.)

OBITUARY.

JAMES CLERK MAXWELL, F.R.S.—By the early death of Professor Maxwell in his forty-ninth year the University of Cambridge has sustained a loss which will be felt as personal by all students of physical science. He entered perhaps more thoroughly than any of his contemporaries into the splendid inheritance of scientific speculation left behind by Faraday, and though he has made invaluable additions to that inheritance, the world must ever regret that to one so gifted the time should have been denied for attaining the great results which seem, as we read his papers, to have been so nearly within his grasp.

James Clerk Maxwell, scholar of Trinity College, Cambridge, took his degree as Second Wrangler in the Mathematical Tripos of 1854. He became a fellow of his college in 1855, and accepted the chair of Physics in the Marischal College, Aberdeen, in 1856, which he held until the amalgamation of the College with King's College. In 1860 he was elected Professor of Physics in King's College, London, where he remained till 1865. But he was not in his element as a lecturer, and it was not until his appointment in 1871 to the professorship of Experimental Physics in Cambridge, with the direction of the laboratory which the munificence of the Duke of Devonshire shortly afterwards presented to the University, that he found himself in a position thoroughly suited to his tastes and abilities.

His chief contributions to the progress of science are to be found in the numerous series of his papers. Among the earlier of these are several discussions of great interest regarding the action of colors on the retina, with especial reference to the phenomena of color blindness. His classical paper on Saturn's rings was published in the Astronomical Society's Notices for 1859. In this he proved that the theory of the solidity of the rings is untenable, and that they probably consist of an almost continuous congeries of meteorites. He also had a share in the determination of one of the most important scientific measurements that have been made in recent times, the formation, namely, of the standard known as the British Association Unit of Electrical Resistance, an account of which appears in the British Association Report for 1864.

But the subject which had most attraction for him was the inquiry into the ultimate constitution of matter and the mechanism which produces the phenomena of force, whether electrical or gravitational. Masterly expositions by him of the dynamical theory of gases are to be found in the British Association Report for 1859, the Philosophical Magazine for 1860, the Philosophical Transactions for 1867, the article on "Atoms" of the new Encyclopædia Britannica, and in his only too concise and pregnant Theory of Heat. It is, however, with his attempts at a mechanical theory of electricity, magnetism and light that his name will

be, in all probability, most closely associated in future. He thoroughly endorsed Faraday's rejection of the theory of electrical action at a distance, and sought, with him, to explain all electrical and magnetic phenomena as the results of local strains and motions in a medium whose contiguous parts only act on one another by pressure and tension. Though many of Maxwell's results are contained in his great Treatise on Electricity and Magnetism, the student will not willingly pass over his papers on Molecular Vortices, in vols. xxi and xxiii of the Philosophical Magazine, or his Dynamical Theory of the Electromagnetic Field, in the Proceedings of the Royal Society in 1864. Such luminous imagination together with originality of conception is shown in these speculations that the reader feels Professor Maxwell's genius no less in his own inability to follow them out to their conclusion than in his certainty that the guide we have lost could have knit them together into a magnificent induction if only the full term of life had been allotted to him.

This is the regret that the world of science at large feels. Those only whose privilege it was to study under Professor Maxwell's direction can rightly estimate that genial kindness and sympathy which, no less than his genuine enthusiasm, so inspirited them that they know not whether they labored more from love for their science or from regard for their master.—*Athenæum, Nov.* 15.

APPENDIX.

ART. LIX.—*Notice of New Jurassic Reptiles;* by Professor O. C. MARSH. With Plate III.

NUMEROUS remains of Reptiles from the Jurassic deposits of the Rocky Mountains have recently been received at the Yale Museum, and some of the more interesting Dinosaurs are here briefly described. These pertain to several distinct groups, and throw considerable light on the forms already described from the same horizon.*

Camptonotus dispar, gen. et sp. nov.

The present genus is most nearly allied to *Laosaurus*, but differs in several points. The cervical vertebræ are all opisthocœlous, while those known in *Laosaurus* are nearly plane. The pubis, moreover, is broad and thin in front of the acetabulum, and directed well forward. It has a deep, well marked articular face for the support of the femur. The ischium is expanded at its distal end, and has an extensive surface for union with its fellow. The femur is longer than the tibia.

This genus agrees with *Laosaurus* in one important character, namely, the sacral vertebræ are not coössified. That this is not merely a character of immaturity is shown by some of the other vertebræ in the type specimen, which have their neural arches so completely united to the centra that the suture is nearly or quite obliterated. To this character of the sacral vertebræ, the name of the present genus refers. With *Laosaurus*, this genus forms a distinct family, which may be called *Laosauridæ*.

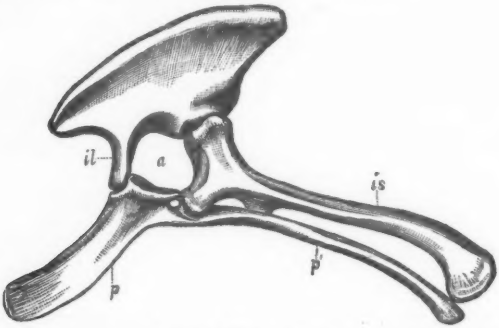
The teeth in *Camptonotus* resemble those of *Laosaurus*, and are in a single row in close-set sockets. The rami of the lower jaws were united in front only by cartilage. There are nine cervical vertebræ, all of which bear short ribs, as in the Crocodiles. The dorsal vertebræ have their articular faces nearly plane. The sacral vertebræ in all the known specimens are separate, and their transverse processes are each supported by two centra. (Plate III, figure 3). The chevrons have their articular faces joined together.

The fore limb is much reduced in size. There are five digits in the manus, supported by nine carpal bones, three of which are united in one on the radial side. The number of phalanges, beginning with the first digit, was 2, 3, 3, 3, 2. The

* This Journal, vol. xvi, p. 411; and vol. xvii, pp. 85 and 181.

form and proportions of the various elements of the fore limb are shown in Plate III, figure 1.

The pelvic arch is quite unlike any hitherto described. In its general form the ilium resembles that of *Morosaurus*, but the proportions are reversed. The massive portion in the present genus is not in front, but behind, as the ischium is larger than the pubis. The relative position and form of the elements of the pelvic arch are shown in the figure below.



Pelvic arch of *Camptonotus dispar*, Marsh; side view, one twelfth natural size. *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* postpubis.

The femur has a long pendant third trochanter, and a prominent ridge to play between the tibia and fibula. The tibia is stout, and somewhat shorter than the femur. The fibula is slender, and shorter than the tibia. The astragalus and calcaneum are distinct. The second row of tarsals contains but two bones. The first digit in the pes was rudimentary, and did not reach the ground. The second, third and fourth were well developed. The fifth was entirely wanting. The number of phalanges, beginning with the first digit, was 2, 3, 4, 5. The structure of the hind limb and foot is well shown in Plate III, figure 2, which is taken from the same skeleton as figure 1.

Some of the principal measurements of the present species are as follows:

United length of the nine cervical vertebræ	565·mm
Length of axis	54·
Transverse diameter of posterior articular face	41·
Length of ninth cervical vertebra	64.
Transverse diameter of posterior articular face	63·
Length of humerus	337·
Length of radius	245·
Length of ulna	260·
Length of femur	565·
Length of tibia	555·

The known remains of this species indicate an animal about eight or ten feet in height, and herbivorous in habit. All the specimens discovered are from the Atlantosaurus beds of the Upper Jurassic.

Camptonotus amplus, sp. nov.

A second species of this genus, about three times as large as the one just described, is represented by various remains, among which is a left hind foot nearly entire. There were three functional digits in this foot, the first being rudimentary, and the fifth entirely wanting. The metatarsal of the first digit is a splint, much curved, and with the apex above. The terminal phalanx of this digit is much compressed, not round as in the smaller species. The second metatarsal is of much greater length. The terminal phalanx of this digit is longer in proportion than that of the preceding species. The third and fourth digits were large and powerful. The main dimensions of this foot are as follows:

Length of second metatarsal	295·mm
Greatest diameter of proximal end	113·
Length of third metatarsal	345·
Greatest diameter of proximal end	150·
Transverse diameter of distal end	102·
Length of fourth metatarsal	305·
Length of first phalanx of third digit	140·
Length of first phalanx of second digit	120·

The remains of the present species are from a lower horizon in the Jurassic than those described above, but within the limits of the Atlantosaurus beds.

Brontosaurus excelsus, gen. et sp. nov.

One of the largest reptiles yet discovered has been recently brought to light, and a portion of the remains are now in the Yale collection. This monster apparently belongs in the *Sauropoda*, but differs from any of the known genera in the sacrum, which is composed of five thoroughly coössified vertebræ. In some other respects it resembles *Morosaurus*. The ilium is of that type, and could hardly be distinguished from that of *M. robustus*, excepting by its larger size. One striking peculiarity of the sacrum in the present genus is its comparative lightness, owing to the extensive cavities in the vertebræ, the walls of which are very thin.

The lumbar vertebræ have their centra constricted, and also contain large cavities. The caudals are nearly or quite solid. The chevrons have their articular heads separate. The sacrum of this animal is, approximately, 50 inches (1·27^{m}) in length. The last sacral vertebra is 292^{mm} in length, and 330^{mm} in transverse diameter across the articular face.

A detailed description of these remains will be given in a subsequent communication. They are from the Atlantosaurus beds of Wyoming. The animal was probably seventy or eighty feet in length.

Stegosaurus ungulatus, sp. nov.

Additional specimens of *Stegosaurus* have been recently secured from several localities, and much new information in regard to the group has thus been obtained. These reptiles belong to the Dinosauria, but differ widely from any of the known suborders. The most striking character, to which the name refers, is the huge dermal plates which protected the animal. A number of these, from two to three feet in diameter, and others of smaller size, were found with the remains of the present species.

The skull is very small, and more lacertilian than in the typical Dinosaurs. The brain cavity is remarkably small.

The vertebræ known are all solid, and have nearly plane or slightly concave articular extremities. The fore limbs are shorter than those behind. In the present species, the humerus is very short, and the ulna has a very large olecranon process. The terminal phalanges preserved are short, broad, and obtuse, as in some ungulate mammals. The femur is long, entirely without a third trochanter, and the ridge between the tibia and fibula is only faintly indicated. The tibia is of moderate length, and the astragalus is firmly coössified with it. The fibula is slender, and united firmly with the calcaneum and lower end of the tibia. The present species may prove to be generically distinct from the type species, *Stegosaurus armatus*,* described by the writer from a different locality.

In one specimen of the present species, some of the more important dimensions are as follows:

Transverse diameter of occipital condyle	44·mm
Vertical diameter	25·
Transverse diameter of foramen magnum	31·
Greatest transverse diameter of brain cavity	33·
Length of third cervical vertebra	85·
Length of humerus	590·
Length of tibia with astragalus	750·
Length of terminal phalanx	85·
Greatest width	70·

Cœlurus fragilis, gen. et sp. nov.

A very small reptile, apparently a Dinosaur, left its remains in the same locality with *Camptonotus dispar*. The most characteristic specimens obtained are vertebræ, which in the dorsal and lumbar region have their centra so much excavated that

* This Journal, vol. xiv, p. 513, Dec., 1877.

the walls are reduced to a thin shell. There are apparently no partitions across their cavity, and the inner surface of the walls is quite smooth. The anterior caudal vertebræ, at least, have essentially the same character. The trunk vertebræ preserved are elongate, biconcave, with high neural arches, united to the centra by suture. The sides of the vertebræ are somewhat excavated, and the openings into the cavity are all small. The cup at each end of the centra is unusually smooth, and regular. The zygapophyses are near together, and stand nearly vertical.

The following measurements will indicate the size of this animal:

Length of centrum of lumbar vertebra	35.mm
Transverse diameter of anterior face of centrum	19.
Vertical diameter	21.
Least transverse diameter of centrum	10.
Least thickness of walls of centrum	1.
Length of anterior caudal	33.
Transverse diameter of anterior face	17.
Thickness of walls of centrum, near middle	1.
Least transverse diameter of centrum	10.

The known remains of this species indicate an animal about as large as a wolf, and probably carnivorous.

Yale College, New Haven, November 18, 1879.

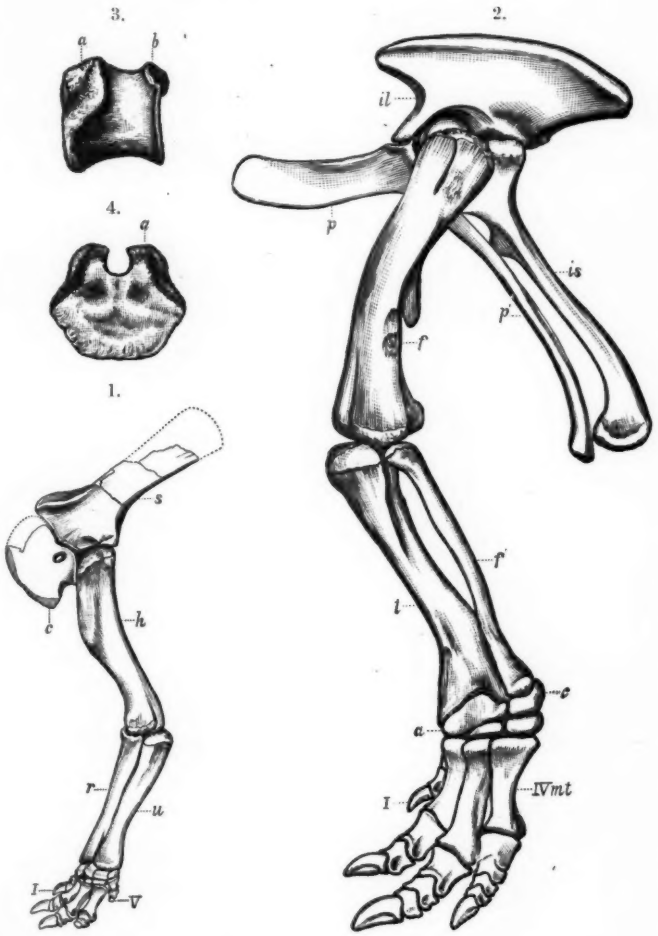


Figure 1.—Bones of left fore leg of *Camptonotus dispar*, Marsh; *s.* scapula; *c.* coracoid; *h.* humerus; *r.* radius; *u.* ulna; I. first digit; V. fifth digit.

Figure 2.—Bones of left hind leg of *Camptonotus dispar*; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis; *f.* femur; *t.* tibia; *f.'* fibula; *a.* astragalus; *c.* calcaneum; I. first metatarsal; IV*mt.* fourth metatarsal. Both figures one twelfth natural size.

Figure 3.—Sacral vertebra of same individual, seen from the left. *a.* anterior face for transverse process; *b.* posterior face.

Figure 4.—The same vertebra, front view. Both one sixth natural size.

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